Infinite Energy

Cold Fusion and New Energy Technology

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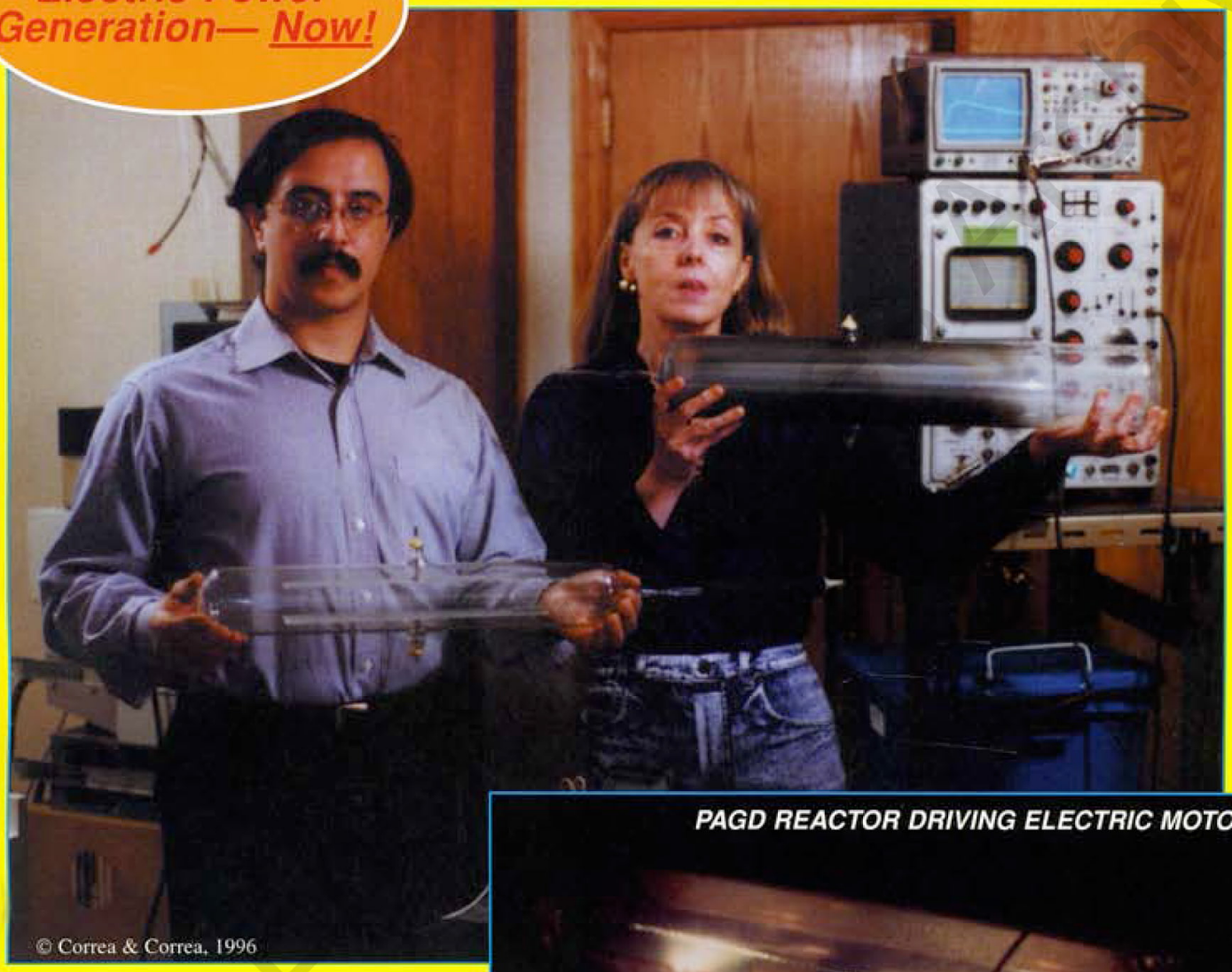

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Infinite Energy

Cold Fusion and New Energy Technology

Volume 2, No.7, March/April 1996

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COVER Photos

Top: Dr. Paulo Correa and Alexandra Correa hold different planar-type PAGD reactors.

Bottom: PAGD reactor driving an electric motor at 50 pulses per second. Anode is the center element.

Photos courtesy Dr. Paulo and Alexandra Correa.
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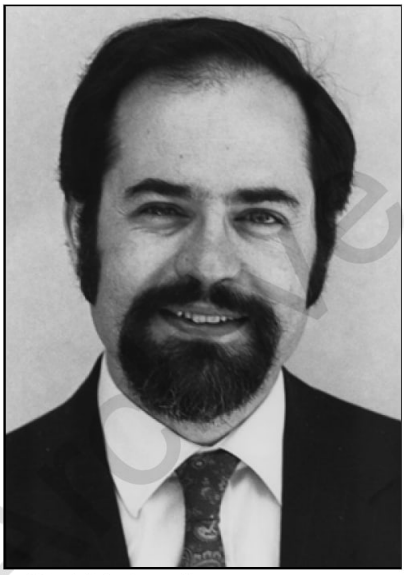
By Eugene F. Mallove, Sc.D.



Cheap Electricity NOW!

Talk is cheap, but this is not just talk. We mark the beginning of *Infinite Energy's* second year of publication with a remarkable development. As our extensive cover story reveals, there is now a verified, meticulously documented technology that is able to produce more electricity out than is input to the reactor. It is the so-called XS NRG™ PAGD reactor of inventors Dr. Paulo and Alexandra Correa at Labofex in Canada.

In development since the mid-1980s and *before* the 1989 cold fusion announcement in Utah, this *Pulsed Abnormal Glow Discharge* system is well on its way to commercialization for electric power generation in vehicles and in homes. It looks solidly protected by U.S. and foreign patent coverage. Furthermore, it is extensively documented in the copious public disclosures, both in the patents and in others graciously made available to this magazine and reprinted here.

The discovery by the Correas is an amazing achievement: to have isolated a regime of self-oscillating electrical plasma discharge that produces electrical energy directly, with no intermediate thermal conversion step, is a wonder. It may not be the only form of "New Energy"— there are other contenders on the way— but it certainly appears to have a commanding lead in the field. We hope that it will "smoke out" other inventors and entrepreneurs, encouraging them to be more energetic in pursuing commercialization of cold fusion and other new energy technology.

How to categorize the PAGD reactor? It is as though electricity is "squeezed" right out of a metal, for example, aluminum. But the ultimate origin of this energy may well be the vacuum energy of space, as its inventors and Dr. Harold Aspden suggest.

Call it what you will, for all practical purposes, this electricity is *effectively free*. The Correas write conservatively:

" ....the cost of kWh produced by this technology is estimated to be *more than* 10 times cheaper than from any other presently available energy source."

The electric car should now be liberated from obsolete primary battery technology. The Correas state: "Moreover, the range of an electrical vehicle utilizing our technology would not be determined by a single discharge cycle of batteries, as those would be constantly recharged by the XS NRG™ power plant. This means that the XS NRG™ electric vehicle could travel >300X the current range of electrical vehicles. And effectively, this range would only prescribe a change of batteries."

Since we now print at least 5,000 copies of this magazine and have better than 1,000 regular subscribers or recipients in over two-dozen countries— many of them highly skilled engineers, physicists, and chemists, there are bound to be those who should be motivated and able to quickly confirm these results. The patents leave nothing to the imagination. It is crystal clear. There are no "magic," proprietary ingredients. This is as it should be. As you will read, the technology has already been run, in effect, in a self-sustaining mode in the laboratory.

Our good friend Arthur C. Clarke, anticipating the New Energy Age, was quoted in the U.K.'s *Daily Express* newspaper (February 24, 1996): "It's absolutely incredible.. what I've seen makes me 95 percent sure that the greatest technological revolution in centuries is almost upon us. The implications are just stunning."

Well, Art, you wanted a "smoking gun" to take you that last 5% of the way to 100% certainty— this may be it. O.K., O.K ... wait till they send a Correa reactor-equipped G.M. Impact electric vehicle to you in Sri Lanka! Since you have reported suffering some major power outages down there recently, maybe you'll settle for a gadget, not connected to the decaying grid, that recharges your computer's batteries?

It is all well and good that we celebrate this new development by the Correas, which was brought to my attention shortly before last April's Third International Symposium on New Energy in Denver, but let us not forget other major developments.

• CETI and its affiliated scientists have now apparently nailed down several of the possible excess heat-producing reaction paths in their Patterson Power Cell. They find that an astonishing cornucopia of transmutations is occurring in the thin metal coatings of their cell beads. This work apparently is confirming the completely independent transmutation studies of Dr. Mizuno and his colleagues in Japan (see page 10 of this issue).

• Motorola tested Patterson cells, and found that with at least one cell they were able to turn the input electrolysis power off, walk away, and have the output power of 20 watts (thermal) continue for at least a half a day! Electrolyte was flowing through the cell at a sustained input/output temperature difference (delta-T) of 15 °C at a flow rate of about 20 ml/min. Hard to fake those numbers!

• There may now be a theoretical foundation for zero-point energy tapping in water vortex systems— a theory that could become acceptable to mainline scientists. Dr. Claudia Eberlein of the University of Cambridge, writing in the May 13, 1996 *Physical Review Letters A,* suggests that the light from sonoluminescense is being extracted from the zero-point fluctuations of space! She shows that this explanation is the most likely one to explain the well-established phenomenon that Julian Schwinger delved into in the last years of his life. And, Eberlein provides specific experimental findings about sonoluminescence that could confirm her theory.

Even the May 4th *Economist* magazine (page 110) notes the significance of the Eberlein paper. Of course, nowhere in Eberlein's writing is there any

New Energy Times / Mallove

mention of James Griggs' Hydrosonic pump (which emits blue light from its water vortex), or any other anomalous O-U machines, such as the Takahashi or Kawai magnet motors (see *Infinite Energy* #5&6), but the article makes *very* clear that this phenomenon — if it really is getting energy out of the vacuum — is one of the "weirdest things in physics."

• The examiners at the U.S Patent Office may be brain dead or terminally confused (witness their typical response to cold fusion patent applications these days — see page 60), but the reality of cold fusion and new energy is a major focus in Japan, as preparations for ICCF6 next October in Hokkaido are underway. Perhaps Germany will be next to ignite. Professor Dr. Josef Gruber and Wolfram Bahmann have started the ball rolling in that country. We reprint their open letter, which should be a model for officialdom everywhere:

Testing over-unity devices in Germany

Dear Dr. Mallove, ladies and gentlemen,

This letter is sent to several persons who may be able to supply one or more over-unity devices for "official" testing in Germany.

A two -hour discussion with a high ranking official and his group in Düsseldorf (the capital of the state Northrhine-Westfalia, which is - with some 17 million inhabitants - the largest state of Germany) has recently brought the following good result:

The State Ministry of Economic Affairs, Technology and Transport in Düsseldorf is willing to support activities in which an over-unity device (or perhaps two or more) is tested by specialists at a Northrhine-Westfalian university or research institute. A positive test result will be a breakthrough in matters of "New Energy" in Germany and a tremendous support of the device tested successfully (great publicity etc.) A negative test result would be disastrous in many respects. For these reasons, the test has to be planned and carried out very carefully.

We plan to coordinate and accompany these testing activities in Northrhine-Westfalia (and perhaps also in other States which might provide similar support of the "New Energy" field.)

Please, let us know soon (for sure not later than end of May 1996) whether you could supply one or more devices for testing. If yes, please, give detailed information which may help us in planning and carrying out successfully the intended tests. A negative test result would be a great problem as you can imagine.

Below we specify a few points which may help us in Germany to test your device successfully and to support thereby this device in particular and Space Energy Technology (SET) in general.

1. We believe that it is absolutely necessary that you provide as much information about a proper test of your device as available. This may mean, for example:

• The leaders of the test group and we as coordinators are instructed in detail (preferably in your laboratory) before the testing in Germany begins.

• We receive results of previous tests, a brief description of the testing procedures used, the name and address of the testing person or group; in case that differences in test results may be due to differences between or among versions of the device tested, it would be helpful to receive from you information about such differences.

2. If there are videocassettes of your device, please, send us soon some copies: two in the American system (NTSC), some 6 or more in the European/German PAL format if available.

3. We receive from you the patent documents in full length.

4. Please, state your financial and legal conditions clearly, in a detailed manner.

5. We are sure that the German test team(s) insist(s) on an agreement with you to publish the test results (with or without prior statistical analysis of the data).

We look forward to your prompt reply.

Prof. Dr. Josef Gruber
Chair of Statistics and Econometrics
Department of Economics
University of Hagen
FAX: 49/2331-987-350

Dipl.-Met. W. Bahmann
European Secretariat of PACE (Planetary Association for Clean Energy) and International Committee of the Institute for New Energy
FAX:49/2443-8221

In closing this commentary, let me say that there is so much more on the frontiers of new energy that we would like to cover in this magazine. Perhaps as the revolution in science and technology accelerates, we will have more resources to do just that. For now, dear readers, we thank you all for your patience, appreciation, and kind support.

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We are an intellectual property clearinghouse serving the interests of both cold fusion inventors and commercial developers throughout the world. Our staff is actively pursuing allowance of U.S. and international patents in most areas of cold fusion effects, including the original, pioneering work of Pons and Fleischmann.

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LETTERS TO THE EDITOR

My name is Nilda F. Alkhoury and I'm the Serials Librarian for Texaco's EPTD facility Library. Could I request a sample copy of the above mentioned journal: *Infinite Energy* Magazine. One of our engineers discovered the title on the Internet and would like to see a sample of it if possible.

Nilda Alkhoury
Texaco EPTD Library
Houston, Texas

•

I thought that you would be interested to learn that my attempts to verify Dr. T. Mizuno's claims of excess thermal power generation by a proton-conducting oxide have been successful. *[Ed. Note: See IE#1, pp.14-17 and IE#4 pp.9-14.]* With a Seebeck effect calorimeter operating at about 400°C, I found that one of the perovskite oxide specimens supplied to me by Dr. Mizuno, in two separate experiments produced positive deviations from the calibration curve by more than four standard deviations so that thermal power was produced that was greater than the d.c. power of alternating polarity supplied to the specimen. In fact, in several episodes excess power was produced without any d.c. power into the specimen. Seebeck calorimetry is particularly appropriate for verifying this phenomenon because it is insensitive to variations of the spatial distribution of power sources and variations of the thermal properties of gases, specimen, and enclosing materials.

Excess power from high temperature perovskites bathed in deuterium gas is especially significant because thermal power generated at high temperatures can be converted to other forms of power with greater Carnot efficiency than thermal power at lower temperatures. Future efforts must be directed to increasing the reproducibility and the power output of the technique, as well as to achieve understanding of the phenomenon.

My paper on this subject has been accepted for publication by *Fusion Technology*, and I expect to present the results at the forthcoming conference on cold fusion in Japan.

Richard A. Oriani
Professor Emeritus and
Director Emeritus

Corrosion Research Center
Department of Chemical Engineering
and Materials Science Institute of
Technology, University of Minnesota

•

I found Bernhard Haisch's article "Zero-Point-Field-Induced Inertia and Gravitation..." published in the Nov./Feb. 1996 issue to be the most interesting and compelling article in the magazine. I would like to see more articles relating to this subject matter.

I wrote to Haisch thanking him for his contribution to your magazine. In return, he sent me a pre-print of a paper he will publish in "Speculations in Science and Technology." I also have obtained a number of papers by one of his co-authors, Alfonso Rueda, from the Internet. If you are interested, I would be happy to forward these papers to you.

While it is not certain that the ZPF is linked to the New Hydrogen Energy phenomena, it may well be. Should the ZPF theories prove out, they will have an impact upon the progress physics in the next century that will be comparable to the revolution that took place at the beginning of this century.

Thank you for all the hard work you have invested in "Infinite Energy".

Jeffrey B. Firestone
Houston, Texas

•

Issue 5&6 arrived! Ohmigod! How did you get the Bearden article? I was practically jumping out of my skin as I read it. Bearden has the right answer--you knew that didn't you? And it must also be the case that the bipolarity of the water molecule and also of the individual H-atom must play a huge role in the explanations of CF (and probably dowsing for water, the "natural energy" stuff of Schauberger) and a truckload of other phenomena. Bearden's paper also explains handily how Tesla's power transmission scheme would have worked, and how it was O-U.

I wondered when the connections between Bearden's work and the CF phenomena would really start to show up. After all, there can be only One physics, so all of the experimental evidence had to point in one direction more-or-less. Holy Moley, Gene!

Jeff Kooistra

•

Since 1983 we have been active in working with free energy and related technologies. Our base is the Danish Institute of Ecological Techniques which is a non-profit society with approximately 250 members in the Nordic countries. Since the announcement of Pons and Fleischmann's cold fusion technology, we have been following this remarkable achievement closely.

We are now subscribing to your magnificent magazine "Infinite Energy" and as an editor of our own Danish journal "difxt-nyt" I would very much like—with your permission— to bring the article by Dr. Edmund Storms in Vol. 1, No. 1, p. 23 into a Danish translation. Please let me know your conditions. Also I would like from time to time to quote news and articles from your magazine if you have no objections? I think it is important to all of us if we do our utmost to spread the knowledge of this emerging technology as much as possible.

With great respect,
Jan Koed

[Editor's note: Permission granted for translation and reprinting of the referenced article.]

•

Well, after my original subscription order of some months ago failed to negoti-

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New Tesla Time Archive

ate its way to you through an unknown e-mail impediment (possibly occurring between my brain and an on screen "send" button, who knows?), my *IE* magazines arrived in good order yesterday.

WOW, were they ever worth the wait! This is thrilling, earth-shaking information, presented in a truly professional looking publication, as well it should be. Thank you to you and your staff for all your efforts in bringing this great magazine into being, and for seeing to it that they were sent out so quickly once you did receive my order.

Fastening my seatbelt for the 'interesting' ride to come...

Rick Monteverde
Honolulu, HI

•

I've just rediscovered the research in cold fusion, and I was wondering how an automobile engine would be constructed using the technology. If there was a constant fusion heat source of hundreds of degrees C, would this vaporize a fluid to turn a turbine shaft or is there another way to convert this heat into electrical or mechanical energy? If a fluid were used, what might it be— is water the best thing? And would the fluid circulate, that is be recondensed and self contained, or would there be a fluid/water tank that would need to be refilled? What might the fusion cell look like if it works on surface area? Would it be beads or possibly a sheet that is rolled into a cylinder. Tell me what you can about how an actual generator/engine might be constructed, if you have the time. Thank you for your thoughts.

Robert W. Hirsch

•

I have the following suggestions based on the Bockris and Minevski article on page 67 of the latest issue of *Infinite Energy* (#5&6):

1. If the data in the article are correct, many accepted concepts of physics will have to be reconsidered.

2. The mass of a hydrogen atom is 1.67343×10^{-27} kg[1] , while the mass of a free neutron is 1.67482×10^{-27} kg. [1] A free neutron has a half life of about 12 minutes[2]. It decomposes into a proton and an electron. This suggests that a free neutron is at a somewhat higher energy state than a hydrogen atom and that a hydrogen atom can likely be converted into a neutron if enough energy is properly applied. The energy required is quite close to the ionization energy of a hydrogen atom, since the weight of a free neutron is very close to the sum of the weights of a proton and an electron.[1]

3. Hydrogen is adsorbed in platinum or palladium as hydrogen atoms[3]. A free neutron is typically absorbed in less than 10^{-3} seconds when passing through materials[2]. A neutron which is part of a nucleus is at a much lower energy state than a free neutron. If a hydrogen atom were converted into a free neutron at the palladium surface and the neutron entered and became part of the nucleus of the palladium atom, considerable energy would be evolved within that nucleus. Could this energy disrupt the palladium nucleus and produce two or more other nuclei? If one or more of such nuclei were unstable various other elements might be produced.

4. Palladium is made up of six stable isotopes. Each isotope might produce a different set of elements under the above conditions.

5. The other elements produced may be similarly attacked by free neutrons produced under these experimental conditions.

6. As the palladium and platinum content of the electrode diminished, the amount of atomic hydrogen absorbed and the rate of energy production would diminish.

References:

1. *Elementary Modern Physics*, Weidner, R.T. and Sells, R.L., Allyn and Bacon Inc., Boston, MA, 1968, Inside cover.
2. ibid. p. 415.
3. *Scientific Foundations of Vacuum Technique*, Dushman, S., ed., Laferty, J.M., 2nd. ed., John Wiley and Sons, NY, 1962 p. 519.

For reasons included in the papers I have sent you, I suspect that the energy required to initiate production of neutrons is supplied by the conversion of hydrogen atoms into the aether.

Paul E. Rowe
Mashpee, Massachusetts

•

One thing that caught my attention in the abstracts of the ICCF5 conference you sent me (along with the ICCF5 video tapes), was the discovery of X-rays from the Pd. In the current issue of *Science* (12 April 1996, p.194) it was reported that comet Hyakutake was emitting high levels of X-rays "roughly 100 times higher than has been estimated." Could this be a result of cold fusion taking place in the comet?

For several years I had toyed with the idea that a significant number of small comets continually bombard the Sun, causing, among other things: (1) the center of the Sun to cool as carbon nuclei (from methane), nitrogen nuclei (from ammonia), and oxygen nuclei (from water) enter the inner regions of the Sun and absorb energy via collisions with protons in the Sun's core; (2) Sunspot activity as current loops of carbon, nitrogen, and oxygen ions break the surface of the Sun; and (3) High solar corona temperature arising from cold fusion near the surface of the Sun. There are tidbits of evidence from a variety of sources that seem to lend credence to the idea of cold fusion in comets as they near the inner solar system. I think this could be a very fruitful area of research.

Richard H. Wachsman
Lowell, Massachusetts

•

I thank you very much for your work. I used to be very interested in the field of new energies (especially Vacuum Energy) since the late seventies. You are now doing a really great and important job in spreading a good digest of what's happening in this emerging field. May the 21st Century be filled with all those wonderful inventions.

Marc P. Hermans
Brussels, Belgium

•

I enjoyed reading your "Cold Fusion and New Energy Technology Resource Guide" a t http://www.mit.edu:8001/people/rei/CFdir/CFfaq.html, and am reminded of an old story:

My grandfather was once on a jury with eleven of the most stubborn people he ever met in his life. The trial was about a man who was accused of stealing a horse. The prosecutor called three witnesses who saw the defendant steal the horse. The defense attorney called twelve witnesses who did not see the defendant steal the horse. The jury brought forth a verdict of "innocent, by preponderance of evidence," so the man got off.

That is what happened with cold fusion.

Dr. Rudolph A. Krutar

•

The double issue [*IE*#5&6] was worth the wait. Of particular usefulness to the readership is the *CF Resource Guide 1996*; if we are to use this magazine as a clearinghouse of scientific information, it is crucial to spell it all out.

Jed Rothwell's notes about James Griggs and HydroDynamics perked me up because I have information which could help his marketing efforts.

Two years ago I moved to Michigan from Vermont. (I know your neck of the woods.) While in Vermont, I went on a fact-finding expedition to Quebec for two weeks to find out first hand what is going on with the Hydro Quebec James River controversy. As you and I know, and few others who read *IE* would know, New England is sensitive to the environmental and cultural problems of the hydroelectric developments in northern Quebec. I learned a lot from that trip (I have a two-hour slide show I have shown to many groups) and want to pass along some valuable information to Mr. Griggs and the new energy com-munity.

What can be widely shared is that

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Quebec, though culturally similar to the rest of North America in the way we consume energy, is very different in how its electricity is produced and consumed. The economic disadvantages pointed out by Mr. Rothwell of a Hydrosonic Pump competing with combustion fuel-fired heating operations may not apply to Quebec. Since Quebec has historically derived 90% of its electricity from hydropower, which is a very energy efficient conversion process, space heating, hot water. and cooking are predominantly electric. Here the Hydro-sonic Pump will have a huge market, as any increase in the efficiency of electricity utilization will be appreciated. Quebec wants to be energy self-sufficient and also environmentally responsible. The Quebecoise argue that hydroelectric power is the best clean and renewable energy source available to them which can realistically meet their present and future needs, despite the concerns of environmental degradation, aboriginal land claims, and detrimental cultural impact.

Best wishes for the Future..

Kenneth M. Rauen
Grand Ledge, Michigan

•

The Thank you *so much* -- for phoning twice, taking time to talk with me, and for sending Numbers 1-6 of *Infinite Energy* so quickly! Enclosed is $30. Sign me up for another year!

I love the articles, your editorials, and every scientific story told! What a comeback has been made! And I do believe, this time— THERE IS NO TURNING BACK! The HEAT IS ON!

May your chosen service be blessed with the light of the great ones—both in and out of incarnation. Your task is as special as it is difficult—but is clearly finding fulfillment perhaps beyond your wildest dreams. The fact is, only the hard work of competent scientific practice remains—and that's going to involve *all of us!*

Now, the question of supreme interest is *why it works as it most surely does!* I'm confident—the answers will come, and I'm so happy to be in touch with someone I know will let us know—when they do come—just as soon as is humanly possible.

Your continued presence on the Internet is doubly reassuring!

Daniel E. Reynolds
Dayton, Ohio

•

Tiny Bubbles

The great mystery surrounding cold fusion has been unraveled. Dr. Roman E. Sioda of the Institute of Industrial Organic Chemistry in Warszawa-Zeran, Poland, has proposed a theory based on fundamental physics describing the formation of nano-sized bubbles in deuterated or hydrogenated materials. Dr. Sioda's analysis shows how the temperatures within these micro-sized bubbles can exceed 100,000 Kelvins. Molten metal transitions to a small plasma where fusions and transmutations can take place.

These temperatures are not in the billions that are alleged to be necessary for hot fusion to succeed. However, there is a miniature magnetic firestorm that accompanies the formation of the bubbles. A new concept called "nano-magneto-hydrodynamics" evolves to supply the additional confinement power to produce miniature mass-energy conversions.

Experimenters armed with this theory can revisit attempts to replicate Pons and Fleischmann's original experiment. Previous failures to replicate did not achieve the nanobubble state in metal lattices. This is because insufficient energetic triggers were absent once metals such as palladium were saturated with deuterium. On the many times that catastrophic destruction of the electrodes occurred, the experimenters mistakenly blamed the results on conventional mechanisms.

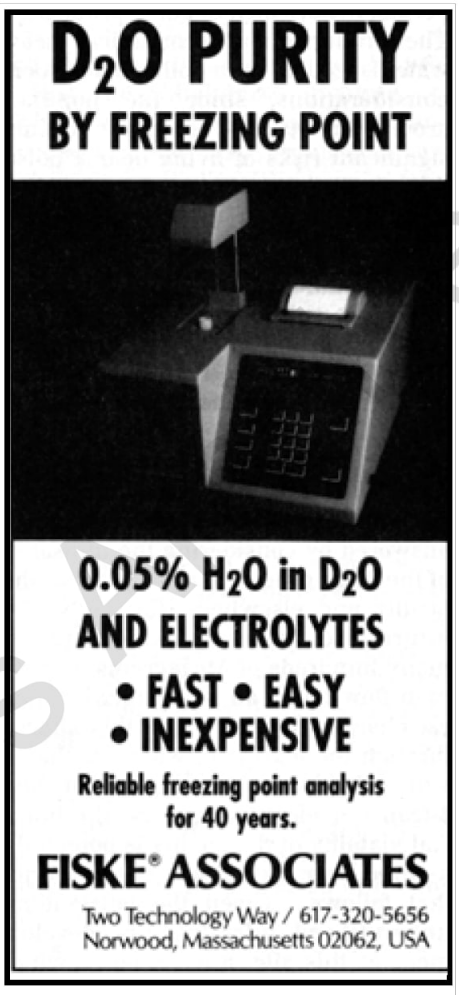
Now, we have discovered that metals such as nickel will create a reaction that yields tremendous energy with the use of ordinary hydrogen. Nano-bubbles that induce energy producing transmutations and fusions are suspected to be the root cause of the excess energy. The design for these devices can be iterated to maximize the power output with Dr. Sioda's new theory.

At maximum power, each nano-bubble is like a miniature sun. This is just the type of fusion condition that has been sought by the expensive Tokamak or the Nuclear Ignition Facility. The nano-bubble is truly a miniature Tokamak fusion generator that forms a spherical vortex of plasma. The vortex not only induces energy rich transmutations and fusions, but also eats up the nuclear debris that is expected by traditional physicists.

Just as computer technology started with large expensive mainframe computers, and then became down scaled to the powerful personal computers as we know them today, success in fusion energy devices will come from cold fusion pioneers working out of a garage. Our world is rapidly depleting the available reserve of hydrocarbon fuels. And the pollution levels of our ground, water and air are becoming unmanageable. A new energy source is needed for an urgent solution to the decay in our quality of life.

There were many unsuccessful attempts at prolonged flight before the Wright Brothers succeeded. The development of cold fusion had a rocky start but the secrets to successful energy production are rapidly unfolding. New technology and new industries should spring up everywhere. Isn't it time that our government and business leaders listened to new ideas for a new future?

Chuck Bennett
Sacramento, California



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• 2ND ANNOUNCEMENT •

International Conference on Cold Fusion ICCF6

Oct. 13-18, 1996 Hotel Apex Toya, Hokkaido, Japan

Sponsor: NEDO NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION

GENERAL INFORMATION

Date: October 13 (Sun.)— 18 (Fri.), 1996 **Venue:** Hotel Apex Toya, Hokkaido
Official Language: English
Sponsored by: New Energy and Industrial Technology Development Organization (NEDO)

REGISTRATION

• August 1, 1996 : Deadline for Final Registration and Deadline for Guaranteed Hotel Accommodation

• May 17, 1996 : Deadline for Submission of Abstracts

REGISTRATION FEES

The registration fee is (40,000 Yen) (includes a banquet and proceedings)
Accompanying person (15,000 Yen)
Student (Free — Registration must be accompanied by a letter of certification issued by the student's head or program director.)

ORGANIZATION COMMITTEES

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WELCOME MESSAGE

We are pleased to announce that the Sixth International Conference on Cold Fusion (ICCF-6) will be held from October 13 (Sunday evening) to October 18 (Friday) 1996 at the Hotel Apex Toya, Hokkaido, Japan. Recent advances in very wide and intensive research from nuclear physics to materials science have made some scientific discussions possible on studies, which have long been neglected in these attractive fields. The purpose of this conference is to provide a forum for scientists involved in active researches on the subjects to interchange their ideas, present recent results, and consider the significance of these new results, demonstration, and development in the theory. We are looking forward to having discussions on these researches.

Chariman, Prof. M. Okamoto

TOPICS

The conference will consist of invited (oral sessions) and contributed papers (poster sessions) on the following topics:

- Excess Energy Phenomena in Deuterium/Metal Systems (Experiments and Theory)
- Correlation Between Excess Energy and Nuclear Products (Experiments and Theory)
- Nuclear Physics Approaches (Experiments and Theory)
- Material Science Studies (Experiments and Theory)
- Innovative Approaches (Miscellaneous Phenomena)

PAPERS and PROCEEDINGS

The ICCF-6 will include contributed and invited papers which will by presented in plenary, oral, and poster sessions. Papers to be presented will by from peers of the Program Committee and selected on the basis of submitted extended abstracts. The details on the extended abstract will be informed in the second announcement; call for paper. The final manuscripts will be published after a review by peers.

TECHNICAL TOUR

A laboratory Tour to the Institute of Applied Energy New Hydrogen Energy Laboratory nearby in Sapporo City is planned for Friday, 18 October.

SPECIAL INFORMATION

The local organization committee plans to support young researchers and students financially for the easier attendance to the conference.

CONFERENCE LOCATION

The conference will be held at Hotel Apex, TOYA, Hokkaido which is located in an ideal position in Sikotsu-Toya National Park. The hotel provides a magnificent, 360 deg round view including Lake Toya. At Hotel Apex Toya, you can enjoy many hot springs, tennis courts and good golf courses. It will take about 1.5 hours by train from Shin-Chitose International Airport to the hotel. The participants will stay in the hotel throughout the conference period.

CORRESPONDENCE

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CLIMATE AND CLOTHING

The average temperature in Hokkaido in October is 10.9 degrees centigrade (average maximum 15.7 °C and average minimum 6.0 °C). The average humidity is about 69%. Appropriate clothing includes top-coats, wool suits, sweaters, and jackets.

ICCF 6th. International Conference on Cold Fusion

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CALENDAR

MIT Cold Fusion Day
January 21, 1995
Cambridge, MA

ICCF5 – Fifth International Conference on Cold Fusion
April 9-13, 1995
Monte Carlo, Monaco

Low-energy Transmutation Meeting (Private) At Texas A&M University
June 19, 1995

The Second International Conference on New Energy Systems and Conversions
July 31-August 4, 1995
Istanbul, Turkey

The 2nd World Hydrogen Summit
September 28
-October 1, 1995
Montreal, Quebec, Canada

16th Symposium on Fusion Engineering (SOFE '95), *with cold fusion component!*
October 1-5, 1995
Champaign, Illinois

Third Russian Conference on Cold Fusion and Nuclear Transmutation
October 1—8, 1995
Sochi, Russia

Power-Gen '95
(CETI cell demo)
Anaheim, California
December 5-7, 1995
(713-963-8833)

New Ideas in Natural Sciences
June 17-22
St. Petersburg, Russia

1996 International World Energy System Conference
June 19-21, 1996
Toronto, Canada

ICCF6—Sixth International Conference on Cold Fusion
October 13-18, 1996
Hokkaido, Japan

ICCF7—Seventh International Conference on Cold Fusion
1997, autumn-winter
Scheduled for the U.S.

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Anomalous Isotopic Distribution in Palladium Cathode after Electrolysis

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(This version edited by Jed Rothwell, Copyright Cold Fusion Technology, 1996)

Key words: Cathodic Electrolysis / Element analysis / Isotopic distribution

Summary

It was confirmed by several analytic methods that reaction products with mass number ranging from 39 to 81, 104 to 136, and 177 to 208 are produced in palladium cathodes subjected to electrolysis in a heavy water solution at high pressure, high temperature, and high current density for one month. Isotopic distributions were radically different from the natural ones.

1. Introduction

Nuclear reactions in a solid electrode at ordinary temperatures have been reported by many experimenters since 1989. However, this phenomenon is still not well accepted among researchers because of poor reproducibility and control. What is urgently needed now is to obtain precise and quantitative relationships between potential nuclear reactions and their corresponding reaction products. If nuclear reactions induced by electrochemical reaction occur in solid electrodes, there must be clear evidence such as the evolution of radioisotopes and radiation. Moreover, the evolution of the reaction products should be explained in terms of the nuclear mechanisms. In this work, evidence which indicates the occurrence of some nuclear reactions is presented, in the form of transmuted elements within the cathode and on the cathode surface. The anomalous isotopic distribution of these elements shows they do not come from contamination. For example, natural copper is 70% Cu^{63}, and 30% Cu^{65}. But the copper found in the cathode was 100% Cu^{63}, with no detectable levels of Cu^{65}. Natural isotopic distribution varies by less than 0.001% for copper.

2. Experimental

Palladium rods used were of high purity (99.97% min.) supplied by Tanaka Noble Metals, Ltd. Impurities in the sample were as follows; B: 110 ppm, Si: 10, Ca: 9, Cr: 10, Cu: 6, Ti: 5, Ag: 44, Mg: 1, Pt: 20, and Au: 23. Nothing more was detected by atomic absorption photospectroscopy. Heavy water was supplied by Showa Denko, Ltd. It is 99.75% pure and includes 0.077 μCi/dm^3 of tritium. The heavy water was purified once in a quartz glass distiller. Reagent grade lithium hydroxide was obtained from Merck, Ltd and mixed with heavy water. Impurities in the reagent were specified as follows; Li_2CO_3: 2% max, Cl: 0.05%, Pb: 20 ppm, Ca: 200, Fe: 20, K: 200, and Na: 200. The anode and recombiner catalyst were, respectively, a high purity (99.99%) Pt plate and a Pt mesh. The Pt metal is specified to contain impurities as follows; Rh: 18 ppm, Si, Cr and Pd; 2 ppm, Au, Ag, B, Ca, Cu, and Fe; less than 1 ppm. Other impurities were under the limits of detection.

Electrolysis was performed in a closed cell made of stainless steel. The cell inner wall was coated with 1 mm thick Teflon. The details have been described elsewhere(1). Before the electrolyte was added to the Pd cell, it was pre-electrolyzed with Pt electrodes at 1 A and 150 deg C for 6 x 105 s (7 days). Electrolysis experiments were performed at a current density of 0.2 A cm^2 or total current of 6.6 A at 105°C for 2.76 x 10^6 s (32 days). The sample electrodes were analyzed for element detection by energy dispersive X-ray spectroscopy (EDX), Auger electron spectroscopy (AES) for depth profiles of the elements, secondary ion mass spectroscopy (SIMS) for isotopic distribution, and electron probe microanalyzer (EPMA) for element distribution.

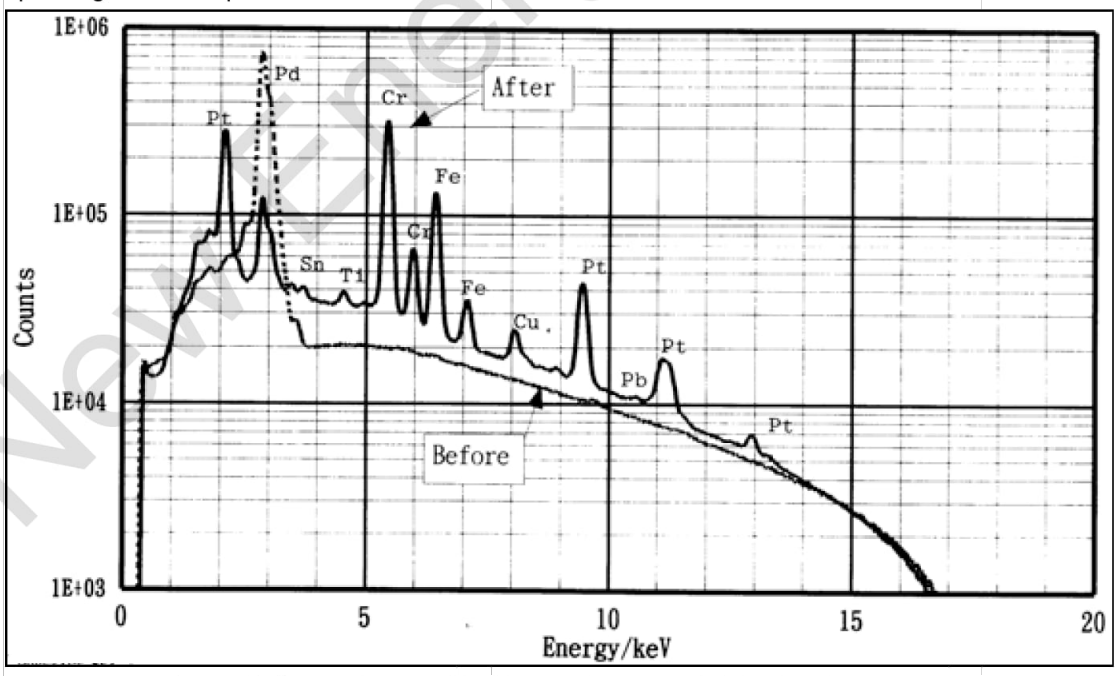

Fig. 1. EDX spectra from the Pd rod before and after the electrolysis.

3. Results

Several elements were detected in the Pd electrode by the EDX method. Figure 1 shows typical results before and after electrolysis. The

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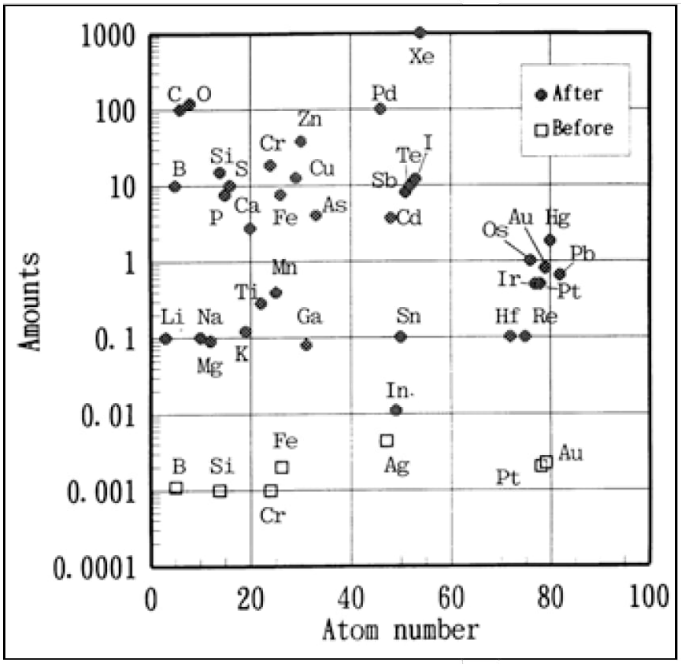

Fig. 2. Amounts of elements observed by various methods, normalized with the Pd peak as 100.

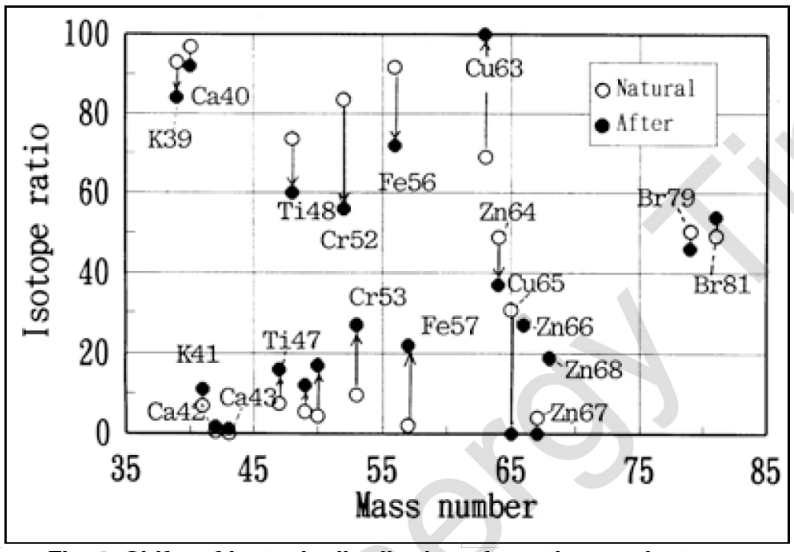

Fig. 3. Shifts of isotopic distribution of reaction products as compared with natural isotopic distribution for mass numbers between 39 and 81.

evolution of Pt, Cr, Fe, Cu and other elements was clearly seen. The amounts detected by EDX, AES and SIMS averaged together are shown in Figure 2. Amounts for all elements were calculated by the peak height of the estimate methods. Amounts were shown normalized with the Pd peak set as 100. Typical counts by EDX and SIMS ranged from 10^2 to 10^6 and were 10 to 100 times higher than the background counts. Thus, the presence of Ca, Ti, Cr, Mn, Fe, Co, Cu, Zn, Cd, Sn, Pt and Pb was confirmed. AES and SIMS measurements were also made after bombardment by Ar^+ or O^{2-} ions, thus removing surface layers, but the element concentrations at 1 [micron]μ below the electrode surface were almost the same as at the surface. Many holes and cracks were observed in the bulk layer, having 1 to 10 μ of opening size. The same elements, having almost the same concentration, were also found at the surface. These elements are mostly grouped in three ranges of atomic numbers: from 20 to 30; 46 to 54; and 72 to 82.

The SIMS analysis showed other elements; As, Ga, Sb, Te, I, Hf, Re, Ir, Br and Xe. These elements, except Xe, are difficult to detect by AES and EDX because the peaks are very close to each other, or lower than the limits of detection. Xe is naturally difficult to detect by EDX because it is in the gas state. The SIMS count numbers ranged from 10^3 to 10^6 where the background counts were as low as ~10, so we have confidence in these results. In Figure 2 we show the peak intensities normalized with the peak of palladium as 100%. The intensity of Xe was 10 times larger than Pd; it may be that the gas was released by bombarding with O^{2-} ions which caused a temperature rise at the sample. Large differences in isotopic distributions compared with the natural distributions were observed by the SIMS method for Cu, Zn, Br, Xe, Pd, Cd, Hf, Re, Pt, Ir and Hg. Elements of mass number between 39 and 82 are shown in Figure 3; Cr, Fe and Cu showed large shifts in isotopic ratios. Especially notable was the fact that no ^{65}Cu peak was observed. Except for a few cases, in generally the isotope abundances are higher for odd mass numbers and lower for even ones, as compared with the natural ratios. In Figure 4, for mass numbers between 100 and 140, Cd and Xe were shown to have large shifts in abundances. In Figure 5, for mass number between 172 and 208, large shifts were seen for Hf, Re, Ir, Os and Hg.

Generally speaking, heavier isotopes increased compared to the natural ratio, and lighter isotopes decreased. For example, ^{24}Mg went from 79% down to 74%, while ^{25}Mg went from 11% to 12%. This rule did not hold for some elements with few isotopes: ^{63}Cu increased while ^{65}Cu was absent; ^{47}Ti increased while ^{48}Ti decreased. The pattern is confusing for ^{111}Cd to ^{114}Cd: a slight decrease, a giant increase, a large increase and compensating drop in heaviest isotope, number 114. Data from some elements are not shown in Figures 3 to 5 because their peaks overlapped with those of other elements, or because they showed only a small difference with natural abundance.

Neutron intensity and energy measurements were carried out simultaneously, in parallel. The neutron evolution rate was sporadic and weak, as previously reported(2), with levels of ~0.4 counts per second. No gases such as He, O_2 and Ar were detected. Excess heat generation was less reproducible, varying from 10^5 to 10^7 joules. (3)

4. Discussion

Essentially the same phenomenon was confirmed five times with high reproducibility at high cathodic current density, above 0.2 A cm^2. Current density ranged from 0.2 to 0.6A/cm^2. Different isotope distributions were obtained, depending on the current density. This will be described more fully in an upcoming paper. It can hardly be imagined that all of the elements found were impurities in electrolyte, electrode or cell. Even if we suppose that all impurities in the system accumulated in the cathode, the amount would be 10 to 100 times smaller than the total amount we detected. Furthermore, it is simply impossible to explain the shifts in the isotopic distribution. Hence, it must be concluded that some novel reactions occurred, resulting in the reactants which were found abundant in the electrolyte and electrode material. We assume the cathode palladium was the starting material for these reactions, but it is possible that impurities and other cell components such as Li, D_2O, Pd, Pt, K, Na, Ca, B, C, Ag and Fe may have provided the starting material for the nuclear reactions.

The palladium surface became rough and porous after several weeks of electrolysis, probably due to hydrogen attack. The current may have increased in such roughened surface areas, which would in turn cause a larger reaction and a higher concentration of the reaction products. Enyo(4-6) reported that the effective

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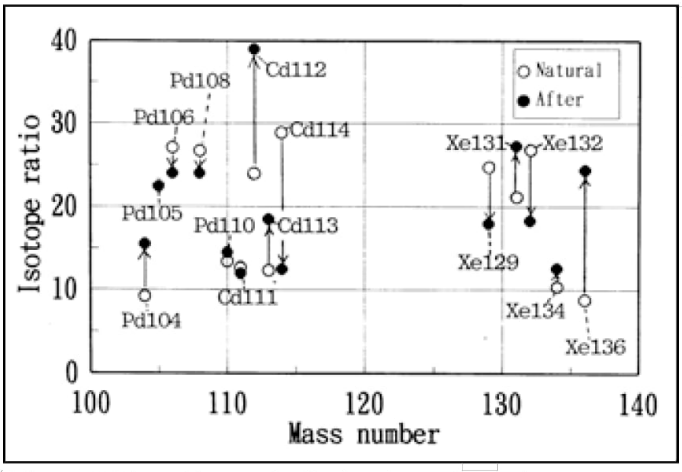

Fig. 4. Shifts of isotopic distribution of reaction products as compared with natural isotopic distribution for mass numbers between 104 and 136.

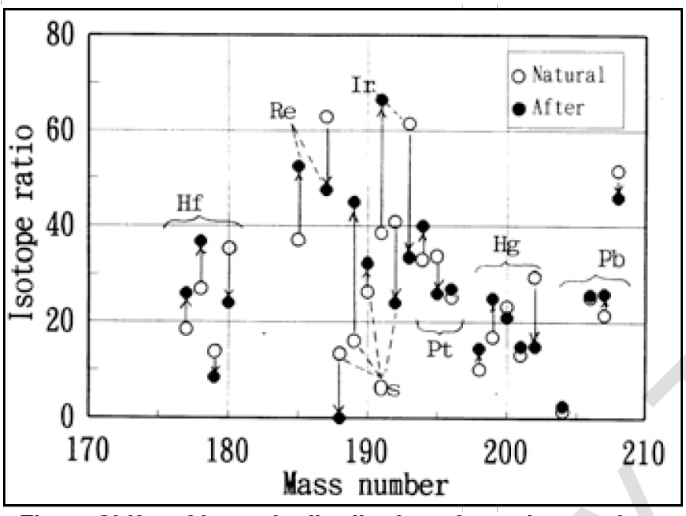

Fig. 5. Shifts of isotopic distribution of reaction products as compared with natural isotopic distribution for mass numbers between 177 and 208.

hydrogen pressure at the hydrogen evolving electrode depends upon the hydrogen atom recombination process which follows the water discharge process. The division of the overpotential between these two steps may be important. It was suggested that at Pd electrodes in alkaline solution the effective hydrogen pressure may rise as high as 10^6 atm(7,8). There may be further increases at local points on a heterogeneous surface. One may even speculate that the hydrogen isotope nucleus sometimes closely approaches the medium nucleus(9). An estimate by Nernst Equation indicates that 5 x 10^4 atm of pressure may be realized at 140 mV of overpotential at the electrolysis current density of 200 mA cm^2 on a flat palladium surface. (10) Furthermore, the pressure distribution depends on the roughness of the surface, because local current density and the partition of overpotential components may vary with roughness.

There are several reports(11-13) of evolution of elements by electrolysis. However, only a few (14,15) demonstrated shifts in isotopic abundance. For a gold electrode(16), which also generated various elements by cathodic electrolysis, different isotopic distributions were seen. In this case also, the reaction sites were unevenly distributed on the surface. Typically, the active points may have occupied about 10^{-6} cm^2 areas and numbered 10^4 to 10^5 per cm^2 at the surface. Thus, the current is likely to be concentrated at localized points 10 to 100 times higher than average. Such high pressure can induce neutrons to enter into heavy nuclei and successively form an unstable heavy nucleus(17). If the reactions start from palladium as the electrode material, fusion and fission may take place simultaneously. Several possible reactions might be considered:

$$^{108}_{46}Pd + 2\,^{2}_{1}D \rightarrow ^{108}_{46}Pd^{4}_{2} \rightarrow ^{116}_{48}Cd\,,$$

$$^{108}_{46}Pd + 4\,^{2}_{1}D \rightarrow ^{108}_{46}Pd^{8}_{4} \rightarrow ^{116}_{50}Sn\,,$$

$$^{108}_{46}Pd + 8\,^{2}_{1}D \rightarrow ^{108}_{46}Pd^{16}_{8} \rightarrow ^{124}_{54}Xe\,,$$

$$^{102}_{46}Pd + 8\,^{2}_{1}D \rightarrow ^{102}_{46}Pd^{16}_{8} \rightarrow ^{118}_{54}Xe \rightarrow ^{118}_{50}Sn + 4\beta^{+}\,,$$

$$^{104}_{46}Pd + 8\,^{2}_{1}D \rightarrow ^{104}_{46}Pd^{16}_{8} \rightarrow ^{120}_{54}Xe \rightarrow ^{120}_{52}Te + 2\beta^{+}\,,$$

$$^{105}_{46}Pd + 8\,^{2}_{1}D \rightarrow ^{105}_{46}Pd^{16}_{8} \rightarrow ^{121}_{54}Xe \rightarrow ^{121}_{51}Sb + 3\beta^{+}\,,$$

$$^{106}_{46}Pd + 8\,^{2}_{1}D \rightarrow ^{106}_{46}Pd^{16}_{8} \rightarrow ^{122}_{54}Xe \rightarrow ^{122}_{52}Te + 2\beta^{+}\,,$$

Here, the bottom subscript at the right-hand side of the intermediates represents the proton number and the top superscript represents the total nuclear number which is connected with nucleus as the hollow atom. It can be assumed that these particles will stay in a stable orbit according to

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their quantum spin number as the same concept with electron orbits. The connecting nuclei are caught into medium nuclei by the force of high external pressure.

Other reactions have to be assumed because many light elements were observed. They may be as follows:

$$^{108}_{46}Pd + 2D \rightarrow ^{51}_{23}V + ^{4}_{2}He$$

$$\rightarrow ^{50}_{22}Ti + ^{52}_{24}Cr + ^{4}_{2}He$$

$$\rightarrow ^{48}_{20}Ca + ^{52}_{26}Fe + He$$

Generally, one can write the fission reactions as follows:

$$_{46}Pd + 2D \rightarrow _{a}A + _{46-a}B + He$$

In the case of platinum deposited from the aug. electrode to the Pd electrode surface, some reactions may be involved, such as:

$$^{196}_{78}Pt + 2^{2}_{1}D \rightarrow ^{198}_{78}Pt^{4}_{2} \rightarrow ^{202}_{80}Hg \ ,$$

$$^{196}_{78}Pt + 4^{2}_{1}D \rightarrow ^{198}_{78}Pt^{8}_{4} \rightarrow ^{206}_{82}Pb \ ,$$

They may induce fission reactions as follows:

$$^{194}_{78}Pt + 2^{2}_{1}D \rightarrow ^{136}_{54}Xe + ^{58}_{26}Fe + ^{4}_{2}He$$

$$^{196}_{78}Pt + 2^{2}_{1}D \rightarrow ^{136}_{54}Xe + ^{60}_{26}Fe + ^{4}_{2}He$$

$$^{60}_{27}Co + \beta^{-}$$

$$^{96}_{78}Pt + 2^{2}_{1}D \rightarrow ^{136}_{54}Xe + ^{60}_{28}Fe + ^{4}_{2}He$$

$$^{60}_{28}Ni + 2\beta^{-}$$

Atomic numbers of 20, 28, 50 and 82 are called magic numbers. Here, $^{136}_{54}Xe$ nuclei are abnormally increased, and hence the number of neutrons changes to magic number 82, and especially stable nuclei are selectively produced. In this way, the isotopic distributions of the products after electrolysis can be explained in terms of the difference of binding energy of the nuclei.

It must be admitted that these reactions have no solid, detailed theoretical basis yet, but in broad terms this can explain most of the elements which were observed. One may also imagine that as such transmutation reactions were presumably taking place during the electrochemical process, they are likely to be connected with other phenomena such as hydrogen embrittlement and local corrosion.

5. Conclusion

Anomalous evolution of various elements in palladium electrodes was confirmed after high current density cathodic electrolysis under high temperature and pressure for a long time. The following conclusions were drawn:

(1) The mass number of the evolved elements were distributed roughly in three groups: 20 to 28, 46 to 54 and 72 to 82, with the amounts, respectively, >50 %, 10 % and <5% compared to palladium.

(2) These evolved elements were found on the surface, and also in the bulk of the electrode, but in amounts 10 to 100 times smaller than on the surface.

(3) Many evolved elements accumulated in holes and cracks on the electrode which formed during electrolysis.

(4) Some of the evolved elements have isotopic distributions drastically different from natural ones, especially for Cu, Ze, Br, Xe, Pd, Cd, Hf, Re, Pt, Ir and Hg.

(5) Gaseous Xe was noteworthy because it was so abundant. Xenon is particularly unlikely to be a contaminant because metals do not absorb noble gases, and because the cathode was degassed in a vacuum at 473 deg K for 20 hours.

(6) The elements in the bulk layer changed in concentration with depth and showed shifts of isotopic distribution.

(7) Light elements such as O, C, Ca, Na, Mg and Al showed small isotopic shifts.

(8) Ni and Co were also confirmed but their isotopic distribution could not be measured because their SIMS peaks overlapped with those of other elements.

(9) The isotopic distributions of Pd and Pt were also shifted.

(10) We conclude that nuclear reactions must have occurred during the electrochemical process.

6. Acknowledgment

The authors acknowledge financial support from the Association of New Hydrogen Energy in Japan.

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The Third International Symposium on New Energy—*ISNE3*
Denver, Colorado April 25-28, 1996

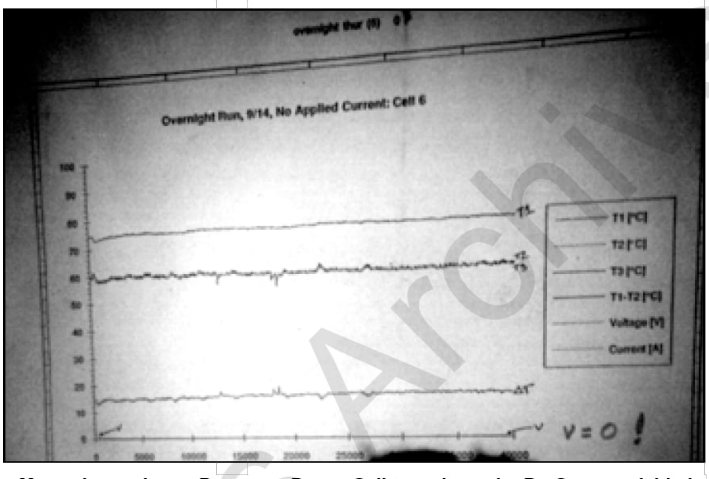
by Eugene Mallove

Offered a choice between attending one of the International Conferences on Cold Fusion (ICCF's) and and an International Symposium on New Energy, one might well choose the latter—though it would be a difficult choice.

As a "cold fusioneer," who has attended all the ICCF's (except for ICCF2, Como, Italy, 1991), this was my first ISNE meeting in Denver—the last two were also held in this city. I had seen the very thick compendia of papers from the last ISNE meetings, and was intrigued enough to come. Besides, the Academy of New Energy in Denver, which sponsored the meeting, graciously invited me to be a dinner keynote speaker and to give a cold fusion "workshop"—one of several given by other speakers too.

This was the year that "cold fusion" met up with New Energy at an ISNE meeting. Dr. Dennis Cravens, representing CETI (Clean Energy Technologies, Inc.) was there to discuss nuclear products that have been detected in Patterson Power Cells (PPCs), as well as to review data obtained by Motorola in their testing of Patterson Cells. A dramatic high point: Cravens showed a plot from a Motorola test in which electrolysis power was turned off on an already working Patterson cell — for some 14 hours the cell continued to produce 20 watts of thermal output! An enhanced photo of the slide he showed, is reproduced here. Asked later at the workshop how long such apparently steady thermal output typically lasts, Dr. Cravens replied that the half-life of this "heat after death" output is 2-to-3 days.

At his workshop [which you can view by purchasing from Cold Fusion Technology one of the many ISNE3 tapes, see page 17], Dr. Cravens also demonstrated a small PPC of new design, which he had carried with him in his luggage— a rugged technology! After come glitches with wiring, he quickly had it warmed up with a delta-T around 4.5 °C at 30 ml/min flow rate of electrolyte. I confirmed the approximate flow rate afterwards myself (34 ml/min). The input power was a paltry 0.3 watts. The output power was over 8.4 watts, giving a nice 28/1 power ratio. Cravens publicly stated that they have confirmed by multiple measurements at multiple labs that the nickel electrode is "nuclear burning," in part to form such elements as copper (Z=28 to Z=29) and palladium is going to silver (Z=46 to Z=47), at least for some of the reactions. They have used special ultra-clean cells to confirm these measurements. The CETI people were exuding confidence—the very fact that they showed up and were so public about previously closely-held results indicated that they believe their nuclear results are solid. It is reported that Nuclear Engineering Professor George Miley of the University of Illinois will later this summer publish or announce his group's nuclear results. Noteworthy at ISNE3 was that Cravens pointed to Dr. Mizuno's recent transmutation results (see this issue of *IE* pages 10-13) as being typical of what CETI and its affiliated labs are seeing in the metal of beads from operated PPCs.



Motorola results on Patterson Power Cell test shown by Dr. Cravens, labled "Overnight Run, 9/14, No Applied Current: Cell 6," Input electrolyte temperature hovers around 60 °C, output electrolyte temperature hovers steadily around 75 °C for 40,000 seconds with no sign of dropping. Cell voltage is zero! *(Photo: E.F.M.)*

Everyone in the cold fusion/new energy field is looking out for *THE* "smoking gun," the device that will be so spectacular, carefully confirmed, and commercially viable that it could lead to the rapid end of the "Over-Unity War." Such a smoking gun now exists and was introduced at ISNE3—a confirmed over-unity electrical technology that is patented world-wide and in the U.S. by Dr. Paulo Correa and his wife Alexandra. [U.S. Patents: 5,416,391 (1995) "Electromechanical transduction of plasma pulses" and 5,449,989 (1995) "Energy Conversion System," #5,502,354 (1996) [Direct Current Energized Pulsed Generator Utilizing Autogenous Cyclical Pulsed Abnormal Glow Discharges," and World-wide, WIPO, WO94/03918 "Pulse Generator" (1994).] The two scientists are from "Labofex," a research company in Concord, Ontario, Canada.

Dr. Correa appears to be a very careful scientist—with both a physics and biophysics background. He spoke at the conference in the most measured tones, but what he had to offer is mind-boggling. He and Alexandra, who is an expert in the glass blower's art, have developed a novel plasma-discharge tube that self-pulsates, being fed by nothing more that *direct current* from a battery pack. The device outputs also *direct current* into an output battery pack. Over and over again they have achieved results like this over-unity run: 37.7 watt-hours electric power input and 183 watt-hours output into the output battery pack. (As most will realize, it is easy to

Dr. Dennis Cravens holds newly designed Patterson Power Cell at ISNE3 talk.

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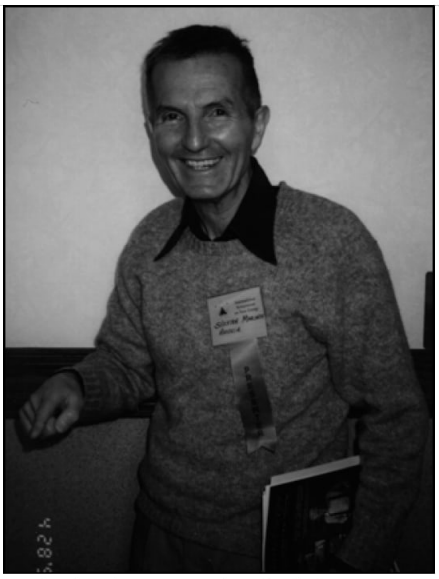
Dr. Harold Aspden at ISNE3, claims experimental and theoretical evidence for "vacuum spin" energy being behind many over-unity processes. Dr. Aspden joins the *Infinite Energy* Scientific Advisory Board*(Photo: E.F.M.)*

measure DC power and integrate it— no issue of phase angle between current and voltage or anything like that.) Because of the extraordinary turning point that this technology represents, we devote considerable space in this issue to the work of the Correa's —pages 18-38. This compendious documentation—only a small portion of what they have published and patented—speaks for itself.

Dr. Correa told me that Labofex has achieved "manual self-sustaining," which means that just by shifting the output pack charge to the input periodically—"ping-pong mode," the device can continue to run and produce considerable net output power. The forementioned data set is an average power ratio of 483%, *but remember that is pure, free, 383% more electricity out than went in*. There is *no* thermal conversion process whatever in this technology. It is straight, blessed electricity! In fact, there is additional energy output in the form of wasted heat, not accounted for in the above numbers. The have demonstrated ratios up to 9/1 already. Clearly, this technology seems destined for rapid commercialization.

The Correas are working with others to get this technology into automotive application and into integrated home electricity heating as soon as possible. At the very least, this technology means that the electric automobile may very soon rule the world, since the PAGD reactors can be used to charge advanced electrochemical batteries. They are, of course, working on the power conditioning problems to make



Dr. Stefan Marinov claims that his "Siberian Coliu" machine runs indefinitely, in self-sustaining mode, against resistance forces. Shown here carrying a copy of our favorite magazine. *(Photo: E.F. M.)*

the electricity suitable for AC power in homes. (He hinted they have gone farther with this circuitry than he has publicly announced.)

Where does the energy come from, you ask? They answer: it may be extracted it from "vacuum spin" -- a concept put forth by Dr. Harold Aspden of the University of Southampton. Dr. Aspden also spoke at ISNE3 about his theories and experiments, which appear to show serious electromagnetic anomalies in magnetic motors. (He has graciously agreed to join *Infinite Energy's* Board of Scientific Advisors. Dr. Aspden, a physicist, formerly was a patent expert for IBM in the UK.) Another good point: The Correas have obtained microphysical evidence from their metal cathodes, which they suggest shows why the Aspden theory may be correct.

Dr. Stefan Marinov of Austria—a theoretical physicist and engineer —talked at great length about his implementation of modifications to standard Lorentz force law, which he has embodied in a motor that he says continues to operate by itself indefinitely—dubbed the "Siberian Coliu" machine. He recently took out a full page "ad" about this in *Nature* magazine— actually a technical paper! His device, he says, is overcoming fluid friction and other bearing resistance. That is its continuous output. It is not strong enough yet for output power beyond that, but is nonetheless producing at least enough "excess" to drive the motor indefinitely. His work with this motor is detailed in the journal that he edits, *Deutsche Physik: International Glasnost Journal of Fundamental Physics*, Morellenfeldgasse 16, A-8010 Graz, Austria: Fax: 0316/377093]

Jim Griggs of HydroDynamics gave his usual stellar talk. He's now selling pumps all over the world for their conventional applications, but over-unity continues to be reported by users. He stated that the NASA Marshall Spaceflight Center people are engaged in testing the energy balance of the pump and looking into the blue light-emission from the cavitating water vortex. The company's new pump design, he says, gives about 150% over-unity.

And now, a brief word about what may have been the weirdest development of all at the conference. If it is confirmed (the inventor has publicly stated that he will definitely let anyone test it with their own equipment), it is "orthogonal" to almost everything else in the New Energy field. Paul Pantone from Utah has developed over the last 15 years, for want of a better term a *"carburetion"* device that takes water, hydrocarbon fuels, battery acid, or whatever, passes them through a suction device and into the input port of a standard internal combustion engine. At ISNE3 he had a 10-HP Briggs and Stratton engine connected to this device. The mpg -- energy output from the hydrocarbon fuel fraction, he claims, is up to 90 times what one normally gets. He says that testing by standard automotive exhaust monitoring equipment reveals there are *no* signs of *any* carbon in the exhaust. He showed purported standard automotive testing results. When Mr. Pantone, demonstrated the device outside the Denver Hilton South Hotel several times during the conference, the exhaust did look *MIGHTY* clean to this observer —no smoke, no smell. He had just put in pure crude oil and primed the engine a bit with gasoline.

Other strange claims for the G.E.E.T. (Global Environmental Energy Technology) device from Mr. Pantone: It puts out a localized high magnetic field that can erase a video tape within one-second of being placed near the business end of the machine. Ditto for magnetic strips on credit cards. It also does x-ray film fogging, though he says that independent tests show no alphas, betas, or gammas coming out. He has no dogmatic theory of how the device works, though a counter flowing vapor stream into a partial vacuum is its basic process, he says. He is an ex-Californian, who started out 15 years ago trying to make a better carburetor, and initially made a device that got "only" 3X bet-

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Paul Pantone demonstrates his G.E.E.T. device during a break in the ISNE3 sessions. 10-HP Briggs and Stratton engine at left, the "carburetor" and connection to the engine are seen to the right. Loaded with a crude oil (from Chevron!) and water mixture, and primed with a squirt of gasoline, the motor indeed seemed to have no obvious smoky exhaust (as a lawnmower would —even if it *could* run on crude oil). However, scientific testing of this device by independent means is essential before drawing any conclusions. We will try to arrange this as soon as posible. *(Photo: E.F.M.)*

ter fuel mileage. He moved to Utah because there were no regulations against him testing his "carburetor," in an automobile or in his backyard—not so in California. He has an amazing life story, which I think is quite genuine, but of course one never knows—this could be complete nonsense, but let us reserve judgement.

Surprisingly, Pantone has had a hard time getting investors, he claims. They all want "the whole pie." Numerous people (including the research staff of Briggs and Stratton) have apparently looked at this, he says, they all get "scared" and run away after they find out that it is producing cleaner air than room air! Yes, Pantone says it elevates the oxygen level in the exhaust a few percent over input. He also says that the device works spectacularly well with up to 94% H_2O composition mixed with fossil fuel, but the tube to the engine heats up and glows white hot at that condition—too scary to continue, he suggests.

To quote Dorothy from the Wizard of Oz, if this device eventually can be confirmed we are most definitely NOT IN KANSAS! Yet all the other devices, Patterson's Cell, the Correa PAGD, and Marinov's With that, I'll close this all-too brief report on ISNE3. We will be doing follow-up articles on a number of key developments such as the ones already mentioned—and with adequate resources, we will certainly take up Mr. Pantone's suggestion that we test his gadget in Utah.

Dr. Cravens reveals CETI's view and findings of the "nuclear burning" of nickel and palladium as the explanation for the excess energy:

Okay. Let me get some nuclear data. This data actually came from Mizuno, in Japan. He is doing an analysis. He has got this issued in . . . I'll credit Jed Rothwell for translating and all that . . . and I assume that Gene [Mallove] will run this run this sometime. *[Editor's note: See Mizuno article in this issue, pp.10-13]* Yeah, probably. It is interesting. But it is out there. Our data is still a little bit under wraps. For various reasons. If you say too much you lose international rights. You have got to do it right. So we're on the conservative side. But this dotted line, we've got palladium before, and after all these elements pop up. Now the question is impurities or not. If you look in . . . Bockris has some work. He has a little quickey in the latest edition of Gene's magazine *[Infinite Energy #5&6]*. ...in there, they do a depth profile. The materials are being formed at depths that could not be diffused into the metal, at those kinds of times and pressures. The other thing that's a little bit more interesting is . . . you get change of masses, and even more interesting still . . . yes, this is the most interesting one, is: here is the isotopic ratio versus mass numbers. So we are going from calcium, potassium, and bla bla, over to the bromine [mass numbers 35 to 85]. That period of the chart, so from left side to the right side

Continued on page 70

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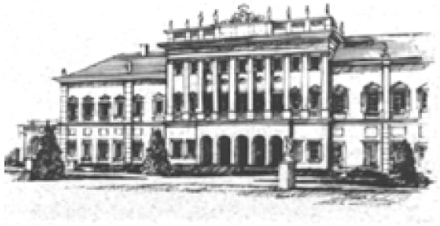

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XS NRG™ Technology

by Dr. Paulo Correa and Alexandra Correa

Labofex—Experimental and Applied Plasma Physics
42 Rockview Gardens, Concord, Ontario, Canada L4K 2J6

What is the XS NRG™ technology?

It is a pioneering cold plasma method to generate substantial quantities of electrical power or work in excess of input power, which employs specially designed plasma reactors we term LGEN™. The cold plasma is formed in either of two regimes: the self-generating, spontaneous auto-electronic emission-triggered pulsed abnormal glow discharge (autogenously triggered PAGD, or PAGD for short), *originally discovered and isolated* by the Correas, and the externally interrupted "vacuum"-arc discharge (IVAD). By utilizing very large anomalous cathode reaction forces that are created either by a self-pulsed (autogenously triggered PAGD) or by an externally pulsed (IVAD) autoelectronic plasma discharge, the XS NRG™ technology releases energy in excess of breakeven from charged metals in a vacuum. The technology basically consists of a direct electrical conversion of energy, the output of the XS NRG™ System being much larger than the power consumed at the input.

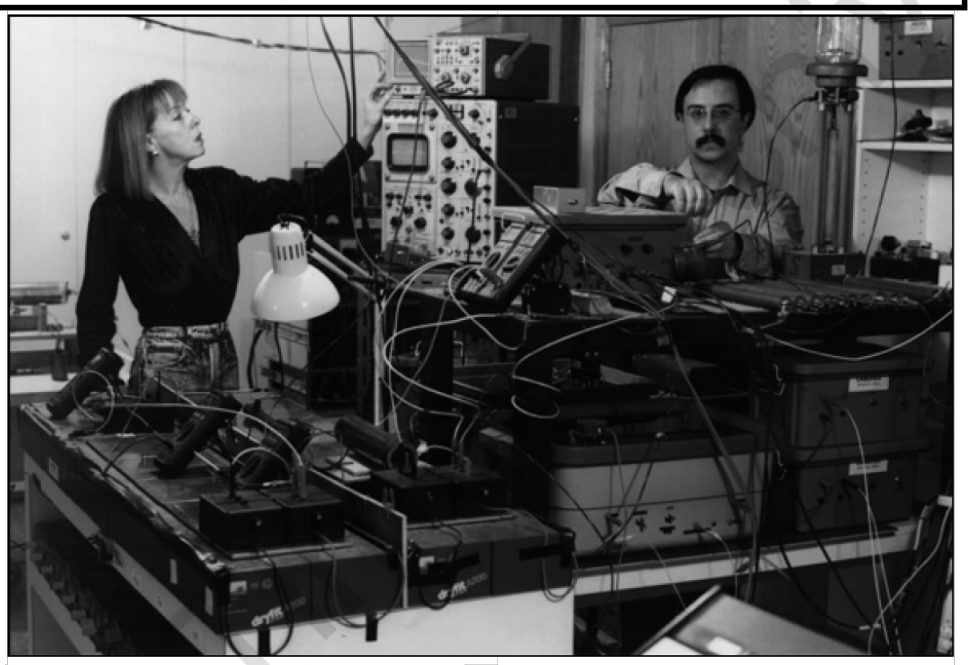
XS NRG™ technology is composed of:
1) the PAGD/IVAD plasma tube or reactor, referred to as the LGEN™ reactor, standing for Labofex Pulse Generator, which encompasses different design types (planar, coaxial, rotating cathode-type, etc), and which is protected by such issued patents as US #5,502,354 and GB #2,284,093;
2) DC-AC inverter applications, to drive transfers, relays or motors, and in particular the Labofex Motor Drive, LMD™, protected by issued US patent #5,416,391;
3) The XS NRG™ Conversion System applications, eg to charge batteries, protected by issued US patent #5,449,989.

How does the XS NRG™ System achieve power generation?

To answer this question, we must examine the System in some detail:

1. Power input: System drivers.

1.1. The System can be driven from any source of constant DC, pulsed DC or pulsed AC. Typically these sources are line-fed power supplies or pulse generators, portable generators, battery packs, digital pulse shapers, etc.



Inventors of the XS NRG™ System, Dr. Paulo N. Correa and Alexandra N. Correa, shown with XS NRG™ system modules at their Labofex, Experimental and Applied Physics laboratory.

1.2. The driving power is fed to one or more of several types of cold-cathode reactors, having relatively specific characteristics, such that a pulsed plasma discharge is repeatedly struck across a vacuum gap under optimal conditions for the desired low-field emission in either the PAGD or the IVAD regimes.

2. Reactor regimes of plasma discharge.

2.1. Utilizing specific operational and physical parameters and particularly advantageous cathode fuels, an autogenous regime of pulsed plasma discharge (PAGD) provoked by spontaneous and quasi-regular auto-electronic cathode eruptions, can be sustained in LGEN™ reactors with *constant DC inputs.*

2.2. Utilizing *pulsed DC or AC sources, or a constant DC source* whose flow is mechanically or electronically *segmented*, one can artificially interrupt a "vacuum"-arc discharge (IVAD) to make it behave similarly to the plasma condition of the emission-triggered, pulsed abnormal glow discharge.

2.3. With either PAGD or IVAD regimes, very large anomalous cathode reaction forces are set up in the LGEN™ reactor, by the longitudinal discharge pulse, and these forces transduce peak currents much greater than the maximum input currents. Under conditions of complete pulse extinction, most of the charge carriers generated in the vacuum gap can be retrieved at the collector.

2.4. Identification of an area effect that increases the spontaneous pulse frequency of the PAGD discharge, led to the discovery of an associated effect: reduction in breakdown and extinction voltages for large area reactors, which may be exploited advantageously in either plasma regime and the design of LGEN™ reactors.

2.5. Utilizing small experimental LGEN™

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reactors with a typical cathode area, peak PAGD currents may reach as high as or higher than 150 to 200 A per pulse, across the reactor gap. Comparable or much larger peak currents may be attained with the IVAD plasma regime. Both PAGD and IVAD conditions of field emission are realized under low applied field, either autogenously, or mechanically, electronically or as a function of induction triggers. Commonly, low fields of 10-100 V/cm are utilized for this purpose. A typical experimental reactor, as described, will output from 50 to 1,000 W. at average pulse rates of 1 to 10 PPS. All conditions being the same, greater power outputs are possible with stronger fields, larger reactive areas and higher charge densities.

3. System capture of released energy and output.

3.1. Energy present at the collector during reactor operation, may be captured (with variable efficiency) and converted, in the remainder of the XS NRG™ System, in two ways:

A) For DC power output applications (eg to run DC motors, to charge batteries, flywheels, etc.), the reactor output is transferred and rectified through the appropriate modules.

B) For AC power output applications (eg to run AC relays, AC motors, AC motor generator sets or AC flywheels, etc), the reactor output is shunted by the LMD™ method (Labofex Motor Drive™).

3.2. For frequency dependent applications (eg target rates of battery charging by a DC type output, or desired cycles per second application for an AC output), the pulse rates of the plasma regime can be controlled by one of two methods:

i) In the spontaneous auto-electronic PAGD regime, pulse frequency may be controlled by a variety of geometrical, physical, circuit and operational parameters, anywhere from < 0.1 PPS to >1 kPPS.

ii) In the IVAD regime of plasma discharge, pulse frequency may be controlled by electronic switching of input power in synchrony with the activation of electromagnetic or electrostatic induction triggers and utilizing feedback control mechanisms, preferably to the utilization of shaped fixed-timing input pulses.

3.3. As an added surplus to the electrical conversion method, it is also possible to utilize the heat generated at the electrodes to do work or derive energy. Such heat may, for example, be exchanged with a circulating refrigerant that cools the electrodes and at the same time is used to drive e.g. a heat pump. We must, however, note that all conditions of excess energy generation that we refer to, involve *only* electrical conversion methodologies. In other words, reactor entropy is absorbed by the XS NRG™ System's surplus, as a net loss.

4. Modular structure of the XS NRG™ System:

Aside from small, portable power supply applications of the XS NRG™ System, which may involve a single LGEN reactor, most applications will require multiple coupling of reactors, both in parallel and in series, with respect to their output. This is easily accomplished by the utilization of the XS NRG™ reactor modules. In fact, the XS NRG™ System has been made flexible with respect to the nature of its input power, the desired form of output power, and the requirements of the specific application, by the separation of all of its component subcircuits into distinct modules. This allows modular integration of the XS NRG™ System for any given application and ease of repair and maintenance, while retaining the flexibility required for diverse commercial applications of the XS NRG™ technology and some degree of tailoring by the end user. A total of nine types of modules have been designed to encompass all of the XS NRG™ System applications.

What are the precedents and antecedents of the XS NRG™ technology?

The discovery of abnormal cathode reaction forces in "vacuum"-arc discharges dates back to 1930, with Tandberg and Kobel's separate papers on the presence of plasma counterflows that varied proportionately to the square of the input current. At the time, Tandberg argued that the phenomenon indicated the presence of longitudinal forces in electrodynamic interactions. However, admission of this reality was problematic for the relativistic law of Lorentz, and quantum theory treatments of field emission, such as Fowler-Nordheim theory, as well as Biot-Savart treatments of Ampere's Law, completely ignored this aspect of electrodynamics.

In the past twenty years there has trickled what is now a mounting body of evidence for the existence of these longitudinal forces in VADs, relativistic electron and ion beams, water arc launchers, coupled wire circuits, etc. Largely because of the stimulating work on the law of electrodynamics carried out by H. Aspden, this field has also received a deserving theoretical attention in the past ten years.

More recently, the work of G. Spence has exploited these forces in a magnetic plasma generator, circulator and separator that is claimed to produce energy outputs greater than the input spent in operating the electromagnets and the thermal VAD ion injector cathodes. However, details on the performance of Spence's machine are rather scanty.

Longitudinal force interactions have also received much attention by researchers investigating Tesla magnifier transformers, as well as by theorists and researchers that have proposed the stochastic electrodynamic model known as the vacuum Zero-point energy field. Recently, K. Shoulders patented an externally pulsed, microscopic high field-emission or pure field-emission-based energy conversion system utilizing point electrodes or electrodeless sources, which generates microscopic charge entities (which he terms EVs) that behave as coherent "electron bundles," to obtain theoretical energy outputs 96x greater per pulse than the input energy. However, Shoulders gives no details of the performance of his inductive-capacitive coupling method to capture some of the excess energy produced. Moreover, the EV emission process is limited by its microscopic scale, and the presence of Joule and Nottingham heating at the tips of the emitters will greatly limit their lifetime.

Labofex's research in this field of investigation originally concentrated on the coldcathode transition region between the normal glow discharge (NGD) and the "vacuum"arc discharge (VAD), ie in the abnormal glow discharge region (AGD), in diode and triode reactor designs that are part of the LGEN™ group of reactors. In distinction from others, like E. Manuel, who utilized this region by pulsing the abnormal glow discharge *externally in the absence of auto-electronic emission*, with pulsed AC or DC, we found that under conditions of an applied constant DC, certain cathode metals spontaneously and autoelectronically emit quasi-regular, large discrete pulses that segment the coldcathode abnormal glow; hence the name for this regime of plasma behavior, PAGD or *self-pulsed* abnormal glow discharge, to distinguish it from the abnormal glow discharge, AGD, be this a constant AGD or an externally pulsed AGD (Manuel).

This PAGD plasma regime, such as we artificially isolated it, was characterized in our studies as involving an unpredicted mechanism of spontaneous, low field, auto-electronic emission that did not obey the Fowler-Nordheim Law. Pulse frequency of the emissiontriggered abnormal glow discharge could be controlled by a

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variety of factors, and the cluster of electrode area effects (affecting electrical breakdown voltage, vacuum range of PAGD operation and PAGD frequency) then discovered in smooth cathodes, suggested that mechanisms other than microscopic, protuberance-dependent, high-field emission processes were at work in the macroscopic, low-field emission discharges that characterizes the PAGD regime.

Another anomalous aspect of this transitional region regime which we investigated early on, was the development of very large cathode reaction forces in the PAGD regime, which could be increased or decreased as a function of a multiplicity of control factors. Measurements of the currents in the reactor presented highly anomalous values (>lOOx the size of these forces reported in the VAD regime).

Exploitation of these anomalous cathode reaction forces in the XS NRG™ converter circuitry led to the design of experimental Systems for the direct capture of the surplus energy generated and its transformation into work or stored power.

Furthermore, even though the PAGD regime is distinct from the VAD regime by virtue of its independence from the Fowler-Nordheim curve, by the self-generating cyclic instability of the channel and the full extinction of the discharge, it is also affine with it, by virtue of the auto-electronic emission mechanism (intermittent in the PAGD and constant or uninterrupted in the VAD) which they appear to share for the initial plasma ignition process. This work would lead us to the realization that under the optimal conditions of PAGD operation, one could replace the PAGD regime with forcefully interrupted VADs, utilizing either potentials greater than those of the PAGD with on/off switching (mechanical or electronic) or with pulse shaped power inputs, or identical DC potentials to those utilized for PAGD production, in conjunction with synchronous power switching and trigger actions.

Utilization of these forced IVADs in the LGEN™ reactors, though more destructive of cathode fuel than is the spontaneous PAGD, frees the operation of the XS NRG™ System from the inherent limitations imposed to any reactor's operation in the PAGD regime by the maximum input current permissible before the cut-off point is reached when the PAGD decays into a VAD. In doing so, the operation of the LGEN™ reactors in the IVAD regime permits the transduction of much larger peak pulse currents and the concomitant scaling up of the entire XS NRG™ System.

To paraphrase Dr. Harold Aspden, writing in a recent article about any electrodynamic systems where out-of-balance forces arise: in the real physical world ruled by electrodynamic actions, not every action is paired with an equal reaction. Newton's Third Law indeed should be treated in a fashion analogous to the treatment given the Second Law of Thermodynamics by biochemists confronted with having to explain the free noncovalent and chemical energies of living systems. The existence of local acts involving energy transfer to or from the background energy field should be admitted without this having to be construed as an admissible violation of the Laws of Conservation of Energy, when these Laws are given the proper comprehensive treatment they call for.

What are the applications of the XS NRG™ System?

The system has two major configurations:

1. As a DC to AC inverter

2. As a DC to DC converter, or a pulsed AC or DC to DC converter.

1. As a DC to AC inverter the system allows for utilization of a DC source as a means to drive AC devices of fixed or variable frequency input. This may take the form of generation and storage of electric power, or the performance of work by pulsed electromechanical action.

2. As a DC to DC converter, or a pulsed AC or pulsed DC to DC converter, the system allows for the utilization of a constant or pulsed DC source or a pulsed AC source to generate electrical power and store it, such that its retrieval is in the form of a constant direct current output (in conjunction with batteries, flywheels, motor generator sets or electrolytic devices).

These two major configurations of the XS NRG™ System have the capacity for practical use in a number of diverse commercial applications, involving production, storage and utilization of power and/or performance of work, for such diverse usages as locomotion, emergency and remote power supplies, production of heat and light, etc. Because of the substantial reactor power outputs possible, and the relative simplicity of the System's scaling, the XS NRG™ technology may be applied to the modular development of:

- portable electric supplies
- emergency back-up power generators
- HVAC systems
- energy autonomous electric vehicles (AEVs)
- energy autonomous electric sea vehicles (ASVs)
- energy autonomous buildings (ABs)

In line with Labofex's ongoing policy of continuous improvement, engineering blueprints for these diverse commercial applications have been extensively developed. Prototypical AEV designs initially utilizing 10 kW XS NRG™ power plants and autonomous building power plants in the 20 to 50 kW power output range have been extensively investigated. These commercial applications are the subject of the Labofex Series of Technical Reports, the blueprints for the autonomous building modules having been designed in collaboration with M. N. Correa Architects of Lisbon, Portugal.

As an example of these solutions, projected engineering blueprints for an energy autonomous electric vehicle (AEV) indicate that the entire drive train of an electrical vehicle incorporating our technology would weigh *half as much* as the General Motors Impact, with 60% greater power output available, and would run *more than twice* the number of kilometers permitted before eventual battery replacement. Moreover, the range of an electrical vehicle utilizing our technology would not be determined by a single discharge cycle of the batteries, as these would be constantly recharged by the onboard XS NRG™ power plant. This means that the XS NRG™ electric vehicle could Travel >300x the current range of electrical vehicles. And effectively, this range would only prescribe a change of batteries.

It is conceivable that the XS NRG™ technology could equally be applied to power flight vehicles. We believe, however, that better and lighter storage systems than those presently existing would be necessary, aside from the need for further development of the technology in terms of greater specific power and higher peak power capacity.

What are the most important advantages of the XS NRG™ System?

Despite the sustained thermonuclear fusion breakthrough two years ago, and despite the numerous claims of cold fusion and hydrogen power over the last seven years to the generation of energy in excess of breakeven, we believe that Labofex has developed the first commercially viable, plasma-based, excess energy generation

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system. We believe its advantages are tremendous:

• Energy Autonomy: For the first time it is possible to contemplate consumer markets for energy autonomous products that can function with full independence from congested utility grids, because our technology provides a conerollable means to produce and store energy in large quantities.

• Pollution-Free Power Generation: Unlike traditional energy sources, such as coal, oil, gas and nuclear fission, there are no noxious emissions produced by the XS NRG™ System, it utilizes no specific and dwindling natural resources and does not require nor produce radioisotopes.

• Independence From Climatic. Diurnal and Location Factors: Unlike other alternative energy sources, our XS NRG™ technology can consistently sustain high rates of power production independent of such factors as location, time of day or climatic conditions.

• High Rates and Efficiencies of Power Production: The high breakeven efficiencies observed with the XS NRG™ System indicate, together with metallographic studies of PAGD crater formation, a very high specific energy for the reactor cathode fuel; these two properties, when combined with the multiple reactor couplings, and the modular and scaling flexibility of the XS NRG™ System, result in an overall high specific excess power of the system.

• Versatility and Flexibility of Commercial Application: These advantages stem from the modularity of the XS NRG™ System, its compatibility with diverse driver and energy storage systems, the AC and DC system configurations it permits, the flexibility of operation in two separate plasma discharge regimes, the wide controls provided by operational and physical reactor parameters, the multiple coupling of reactors, the scaling capability of the XS NRG™ System and the high efficiency of generation of energy in excess of breakeven by the LGEN™ reactors.

• The LGEN™ Reactor- a "Deactivatable" Vacuum Battery: Unlike primary mechanical batteries that typically consume their electrode fuel once the reaction is initiated (no deactivation being possible), the LGEN™ reactors can be regarded as portable vacuum batteries carrying stored charge in their electrode material, which are activated when needed, or de-activated when no power or work is required.

This deactivation property of the reactor and the System operation process contributes to the greater longevity of the electrode fuel of these electrophysical batteries, when compared to electrochemical cells.

• Lightweight DC->AC Inverter: The reactor and the pulsed AC output circuitry (the LMD™ method) of the XS NRG™ System can be utilized as a drive for AC electromechanical devices, employing a DC source to drive the reactor(s) in turn.

• Abundance and variety of fuels: Even though the number of cathode fuels tested that give optimal results for reactor functioning is limited, their supply is abundant; moreover, fuels of choice, such as aluminum, are recyclable products, and most of the consumed fuel may be retrieved from the reactors.

• Recyclable Reactor Materials: All materials employed in the Reactors, for envelope and electrode purposes, can be equally recycled.

• Lower Cost of Electrical Energy: Given the high breakeven efficiency of the XS NRG™ System, the high specific power of the LGEN™ electrode fuel, its low cost and abundance, as well as the elegant simplicity and modularity of the XS NRG™ System, the cost of kWh produced by this technology is estimated to be *more than* ten times cheaper than from any other presently available energy source.

• Commercial Viability of an Electric Vehicle Utilizing the XS NRG™ Technology: At Labofex, we believe that our power generation method will, for the first time, make the electric vehicle a *truly competitive alternative* to current internal combustion vehicles, with their dependence on oil, and substantially outperform both hybrid vehicles as well as current, grid-dependent EV designs. A vehicle utilizing our XS NRG™ technology would carry its own onboard power generation plant and thus be a true zero-emission vehicle. The onboard power plant would effectively make such a vehicle energy autonomous. With our technology the electrical vehicle, could become: (1) independent of the existing range limitations imposed by battery recharging, as well as (2) capable of repeated, rapid accelerations and (3) lighter in weight.

• Commercial Viability of Modular Pre-Fab or Cast Energy Autonomous Buildings: With the XS NRG™ technology, it will be possible to build modular energy self-sufficient buildings, in urban or remote locations, for housing or commercial purposes. Extensive plans for such autonomous buildings have been developed by Labofex in collaboration with M. N. Correa Architects.

• Industrial Power Applications: Labofex believes that proper development of the XS NRG™ technology will allow large-scale power applications for such usages as metal smelting, local relief of grid congestion, factory power plants, etc.

• Complementarity with Existing Energy Storage Devices: our XS NRG™ technology may be used in conjunction with either battery, flywheel or ultracapacitor systems and does not imply their displacement. What our technology does allow for is the detachment of these systems from their dependence on an external power grid system for recharging purposes.

• Supplementary Advantages: In turn, the lower cost of energy generated by our technology would reduce the clean-up cost of existing waste (in incinerators, etc) as well as stimulate the worldwide economy dependent on scarce, relatively expensive and environmentally unfriendly energy resources.

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Other Applications of the PAGD Technology Besides Energy Conversion

by Dr. Paulo and Alexandra Correa

The PAGD (pulsed abnormal glow discharge) technology comprises, besides energy conversion, a series of other applications made possible by the autogenous pulsatory activity of the auto-electronically triggered PAGD plasma regime and its inverter properties. The following is a summary of these applications.

I. **Pulse Generator Applications**. PAGD reactors in a pulse generator circuit can be utilized to produce and sustain high frequency (>l KPPS)? low current pulses or low frequency (l KPPS), high current pulses. Pulse duration may span <500 nanoseconds to >50 milliseconds, at variable duty cycles.

1. The first obvious application of the PAGD reactor is as an oscillator in a pulse-forming circuit network (1). Sealed PAGD reactors can be coupled in series stages and either tuned to specific frequencies at specific voltage and current input parameters, or made to vary their frequency as a function of applied voltage, parallel capacitance or series inductance. Whereas the plasma pulsation in the PAGD reactor is provoked by a cold-cathode emission, it can also be used, in its quality of a spontaneous oscillator, to flash any vacuum tubes operating in the normal glow discharge region, such as neon lamps, which might be series connected to the PAGD reactor

2. Ionization and electric field motion proximity detectors (1). Set at prebreakdown voltage levels and driven by low current DC sources, the PAGD reactor will undergo vacuum breakdown, glow formation, and auto-electronic emission in the presence of weak radioactivity in proximity to its glass envelope, or in the presence of moving electric fields, including the biological fields of vertebrates.

3. PAGD reactors may also be utilized as pulsed metal varporizers (1). The coating art taught by Manuel (2), which makes utilization of an externally pulsed or flashed abnormal glow discharge is suitable for the deposition of organic polymer coatings on the anode because it does not utilize auto-electronic emission. But, for the same reason, it is unable to deposit metallic coatings on the anode. The autogenously triggered PAGD, however, is particularly suited to do the latter, utilizing any low workfunction metal suitable for PAGD production, such as aluminum, nickel, tin, iron, palladium, silver, gold, etc. Micron-thick metallic films can be generated in this way, and the coating action is not restricted to the anode. In specially designed tubes having small anode areas and large cathode areas, the coating action can be directed towards the envelope (glass, polycarbonate, etc) or towards targets placed so as to intercept the PAGD channels. This can be further controlled by the utilization of transversal electric fields, or magnetic fields, employed to constrict the PAGD channel and direct the deposition of attendant metal vapor.

4. Depending on their design, PAGD reactors can be made to function with very low (<1 mA) and very high (>10A) input currents. This makes them ideal to control energy delivery for small beam injection and lasing applications (1). Tsui's group has shown how unstable glow discharge plasma states enhance stimulated emission in carbon dioxide, high-nitrogen and high-helium lasers (3,4). The glow instability results in pumping cold thermal electrons out of the plasma cavity and greatly enhances the power output of the lasing action. Because the observed spontaneous emission was spurious and of low intensity, Tsui's group ran into trouble trying to exploit the phenomenon with the lasing tubes they built. Lasing columns can be easily fitted to modified PAGD reactors that will provide the desired pumping action at high power to greatly enhance the intensity of the stimulated emission.

5. Given the low-heating of the cathode during PAGD emission, and the capacity of PAGD reactors to transduce high power pulses (>30KWatt peak), they can be utilized at high vacuum to serve as high-power gates capable of switching action, much as pseudospark switches operate. This suggests an application of the PAGD reactor as a high power vacuum switch or commutator.

6. PAGD reactors generate characteristic RF ringing frequencies having wide spectra. This permits their utilization as wide-band noise-generators (1) capable of blanketing AM and VHF frequencies. The effect can be enhanced by the coupling of inductive elements, to configure a transmitter circuit (5).

II. Inverter applications. As a DC to AC inverter, the PAGD reactor allows for utilization of a DC source as a means to drive AC devices (motors, relays, transformers) of fixed or variable frequency input. In this sense, the PAGD reactor is the simplest inverter ever invented. Utilization of PAGD reactors in these circuits shows how the PAGD regime is stabilized by the presence of parallel inductance. Specific applications are detailed below:

1. Transformer applications. In double ported circuits (see (1) Figs. 21A and 21B), single phase transfonners can be operated at the output from the PAGD reactor driven from a DC supply.

2.Motor and relay applications. Similarly, all AC motors and relays can be operated at the output of the PAGD reactor driven from a DC supply (6). PAGD-inverter driven AC motors can maintain their volts to pulse rate relationship constant within a wide frequency range, simply by changing the value of the capacitance placed in series with the motor at the outposts of the reactor. (See (6), Fig. 13). The type of PAGD pulse output is particularly suited to drive magnetic reluctance motors.

3. Multiphase applications. Two-phase transformer or motor applications are possible utilizing either series coupled simple PAGD reactors (see (6), Fig. 6) or special PAGD reactors built with multiple cathodes whose firing sequence is controlled by a variety of methods (5). Multiphase applications can be obtained by exploitation of these basic principles. Utilizing IGBT switching or a suitable substitute switching action, three-phase motors may be controlled by three separate PAGD reactors driven from the same DC supply (see (7), Fig. 43).

III. Thrust applications. Investigation is needed to determine the feasibility of a space-thruster based on the cumulative action of the cathode reaction forces elicited by the PAGD regime. The magnitude of the anomalous cathode reaction forces observed in the PAGD regime suggests that this application could well be a viable one.

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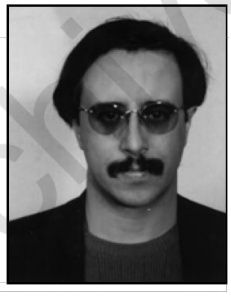

The Correas kindly provided *Infinite Energy* with their extraordiary C.V.'s. The section pertinent to the PAGD devices and their commercialization follows—*E. Mallove*

Business and Research Projects in Physics

• Dr. Correa and his wife, Ms. Alexandra Correa, have managed, operated and financed a Physics laboratory and research project since 1981. This long-term program had the objective of studying the interactions of charged metals with rarefied atmospheres, as well as the nature of diverse plasma discharges. In 1987, the Correas isolated a novel regime of plasma discharge, referred to as the endogenously Pulsed Abnormal Glow Discharge (PAGD). Optimalization of the PAGD function led the Correas to the design of the LGEN™ device, a plasma reactor capable of sustained and controllable PAGD performance. In 1988, Dr. Correa and A. Correa developed the first of a series of electromechanical applications of the PAGD, which led, through the period of 1988-1990, to the simple motor control principles referred to as the Labofex Motor Drive (LMD™). In the 1989-1992 period, investigation of the anomalous reaction forces in the PAGD, led to the design of a capture and conversion method for the energy in excess of breakeven observed to be transduced by these forces. The Correas had in fact discovered a new energy source, which they have named the XS NRG™ power generation system.

• In 1992, Dr. Correa and A. Correa formally created a partnership, Labofex - Applied and Experimental Plasma Physics, for the continuation of these studies. The current emphasis at Labofex lies in the engineering and development of specific applications of the XS NRG~ technology, namely to the design of portable power supplies, energy self-sufficient electric vehicles and building systems.

• Since July 1992, the Correas have filed for five patents (Canada, US and worldwide) that cover all three above-mentioned inventions: the LGEN™ device and its PAGD function; the LMD™ and the XS NRG™ methods.

• Currently, Dr. Correa and A. Correa are engaged in the commercialization and the licensing of Labofex Proprietary Technology to third parties world wide.

• International examination of all applications by the European Patent Office has been completed successfully with respect to all claims, and the applications have been published by W.I.P.O. (World Intellectual Property Organization) .

• Patent protection for the LGEN™ and associated

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Editor's Note: Dr. Paul Correa and Alexandra Correa were very kind to share with the readers of Infinite Energy this portion of an internal Labofex corporate report:

THE LABOFEX TECHNOLOGY

What characterizes the functioning of the Labofex plasma reactors and differentiates them from all the foregoing arc emitter devices and the triggered pseudospark switches (PSS), as well as from Manuel's externally pulsed abnormal glow discharge apparatus, is the method of the discharge initiation as much as the method of its extinction. In fact, the discharge of interest is a pulsed abnormal glow discharge, but this pulsation is *triggered autogenously by a spontaneous electronic emission* under cold-cathode conditions (1-4). Furthermore, this emission-triggered pulsed abnormal glow discharge is repetitively cycled in a self-generating or endogenous action, thus originating quasi-periodic discharge rhythms, whose frequency depends on a host of identified parameters. Both *the spontaneous electronic emission and the self-generating aspects of the discharge* are joint cathode and reactor properties affected by multiple operational and physical conditions, foremost amongst which figure the *metal composition of the cathode* (work function), the negative pressure, and *the cluster of electrode area effects* discovered by Labofex (1-4). Because of the self-generating and self-pulsing characteristics of this discharge, we have termed this veritable regime of plasma discharge we have isolated in special reactors designed to optimalize it (and its volt-ampere characteristic), the emission-triggered Pulsed Abnormal Glow Discharge, or PAGD for short. The PAGD regime is an homeostatic structure (a fluctuating order) of cyclically recurring instabilities. Reactors designed to operate in the PAGD region of plasma discharge constitute effective *pulse generators* (the LGEN™ reactors) susceptible of many more applications than those considered in the present Report (such as detection of proximity fields, stroboscopic light sources, Casing and beam injection, etc).

Unlike pseudospark switches, the PAGD events *do not need* to be triggered externally or by the interposition of third (trigger) electrodes, though they can be triggered inductively or "electrostatically" at prebreakdown potentials. They are in fact *autogenous* events where the observed emissions occur at low applied fields for quasi-reguLuar periods, to generate quasi-regular cathode current jets. Unlike the PSS, which utilizes intermediate gap insulators to prevent the degeneration of the discharge into a full fledged VAD, the PAGD regime of the LGEN™ reactors is self-extinguishing because of the inability of the discharge to complete the channel. Whereas in the PSS switches the discharge channel is formed by the electrode holes or guides, the incomplete PAGD channel is free-forming. Lastly, though not least, the PAGD regime deploys extraordinarily large cathode reaction forces, which we believe to be associated with the anomalous ion counterflow (vaporized cathode metal and gas ions, as well as some neutral atoms) being swept forward by the emitted electronic flux. When this novel plasma discharge regime was isolated and optimized for all of its parameters, measurement instruments indicated the deployment of discharge energies greatly exceeding the energy input responsible for the release of the charged carriers and the initiation of the discharge (73).

The PAGD abnormal reaction forces depend on the intensity of the electronic-emission events that trigger this specific glow discharge, and are thus rather distinct from the externally pulsed, *emission-independent* abnormal glow discharges of the Manuel apparatus (67). In fact, these forces are virtually absent in externally pulsed flashover glow regimes, be they normal or abnormal. Moreover, the PAGD emission frequency is also an electrode area dependent (and cathode material and work-fucntion dependent) phenomenon, quite aside from its operational regulation.

Unlike the VAD, where anomalous cathode reaction forces were first identified for a plasma discharge structure, the PAGD channel is never made complete, and there is thus no steady-state stabilization of the discharge. Whereas the particles leaving the cathode in the Tanberg device had average kinetic energies in the order of 80 to 90 eV (6, 16), the particles forming the PAGD vortex have extraordinarily high energies that typically reach O.5->1 MeV (74-75)! And they do so with typical power input consumptions that are lower by >1 order of magnitude, with cathode fuel losses <2 orders of magnitude and with vapor velocities >lOOx those typically observed in VADs. Because of these characteristics of the emission-triggered PAGD, the regime transduces anomalous reaction forces that are 10^2 greater than those found in VADs. Whereas Tanberg's and Kobel's VAD experiments indicated the presence of $\mathbf{k}\mathbf{i}^2$ reaction forces, where **k** (a figure of merit, or index of the strength of the emission per unit action integral of the current pulse) was of the order of 10^2 (and **i** is the current in absolute units) (6, 7, 21), our PAGD experiments indicate the presence of cathode reaction forces of the order of $10^4\mathbf{i}^2$ (73-75), ie in the **k** range found by Graneau's group for arc-water explosions (50-51, 76-77). This extraordinary behavior is intimately related to the incompressible nature of the medium (76) in which the PAGD occurs, the ratio of the cathode ion mass to the electron mass (22), and the nature of the plasma regime, particularly the PAGD extinction mechanism, which prevents the discharge from reaching a steady-state plasma generation (73).

As Plyutto et al remarked, the Compton model of the reaction forces (8), which proposes that the counterflowing ion stream emerging from the cathode results from the reflection of a fraction (~2%) of the ions striking the cathode, does not explain the dependence of these reaction forces on gas pressure, nor the high velocity plasma streams emerging from the cathode (16). Plyutto's model of an ambipolar mechanism (16), where the electrons sweep the ions forward as a function of the anomalous rise of potential in front of the cathode spot, may well explain the pressure relation of these forces, but not their initiation mechanism nor, a fortiori, the observed coincidence, in the PAGD, of the electron flow and the parallel (or anomalous) ion counter-flow from the cathode. The PAGD function strongly suggests that the anomalous ion flow is an emissive phenomenon driven by the conditions of the spontaneous low-field auto-electronic emission.

It is possible that, as Aspden has suggested (78), field polarization of the vacuum results in reversal of the cyclic motion of the local space lattice (the ZPE), the displacement of which, in turn, causes transient resonant vacuum-field states in the system. A closed system would thus behave as an open system, and *systematically* develop out-of-balance forces (22, 78-79). To paraphrase Aspden on this subject, *it is the correct interpretation of Newtonian Dynamics and Newton's 'rule'* that prevents us from ignoring the reacting field environment of electrodynamic interactions, all the more so as when these interactions develop mutual actions that appear to contravene Newton's Third Law (22, 78-79, 90).

In a speculative fashion, it is indeed interesting to remark that the PAGD energies associated with emitted cathode ions are in the range needed for electron-positron pair creation, a quantum-electrodynamic process that has been implicated by Aspden in both the inductive and stato-dynamic transfer of energy to the field, precisely to explain how the electrodynamic

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interaction between charged matter can originate out-of-balance forces that are directly imparted to the field, without having to be coupled to some of the matter present (22). Interestingly enough, the study of narrow, nonrelativistic positron peaks and of electron-positron coincidences in heavy ion collisions has led to the identification of low-mass "photonium" resonances in the 1 to 2 MeV range (lowest prediction at ~1.2 MeV (81)), which have been theorized as possible e^-e^+ quasi-bound *continuum states* of a pure electromagnetic nature (80-81), suggesting the existence of a new (ultra-nuclear and infra-atomic) scale for QED interactions (81). Lastly, it has been formally shown that pair production can be supported by a photon field in a *nonstationary* medium and in a threshold-free manner (ie for any electromagnetic wave frequency) (82).

From the foregoing, the question obviously arises as to whether there is any contribution on the part of the locally pervasive Zero-point vacuum-field to the tremendous events elicited during PAGD function of LGEN™ reactors. In an extensive patent application recently granted (41), K. Shoulders describes an energy conversion system having some analogies with our own, in that he is able to generate microscopic coherent charge entities (which he terms EVs) by a field emission process (utilizing Nothingham heating of point cathodes or pure field emission mechanisms). By external pulsing of the discharge field, he theoretically obtains energy outputs that are greater than the energy input spent in driving the system. Shoulders has invoked the Zero-point energy of the vacuum as an explanation for the coherent charge behaviour he has identified in his studies (41). While the microscopic EV entities have minimal and *maximal* values of 10^8 to 10^{11} electron charges, and deploy energies in the order of 10^7 erg per triggered pulse, the macroscopic energetic events of the PAGD regime deploy 100-fold greater energies in the order of 10^9 erg per pulse (0.025 to 0.05 mWh/pulse) (74, 75). It is thus entirely possible that the out-of-balance reaction forces observed in the PAGD plasma reactors are the result of the interaction of the apparatus with the local fluctuations of the dynamic vacuum-field. Such behaviour has been described by Aspden, for a dynamic zero-point field obeying the principles of Quantum ChromoDynamics (78).

The quantum mechanical treatment proposed by Fowler and Nordheim (11) to explain arc initiation in terms of the pulling of electrons from metals by *strong or high-fields*, has provided a scientific model for the discrete emission of electrons from the working cathode which, in this process, apparently violate the conservation laws, if just for an instant, and tunnel through the Fermi barrier. However, this quantum mechanical model never adequately accounted for the experimental evidence concerning arc initiation at fields and currents lower than those predicted, for arc discharges which present a Fowler-Nordheim slope. Nor does it account for the LGEN™ operation in the emission triggered low-field PAGD regime, *where the experimental voltage-current characteristic is the inverse of that obeying the Fowler-Nordheim relation for high-field emission* (1-4). Rehabilitations of the Fowler-Nordheim treatment, where the theoretical β enhancement factor has been explained in terms of breakdown produced by heating of cathode microprotuberances (Joule and Nottingham effects), have been proposed to explain the results of VAD studies (13, 83), and these findings have been advantageously employed by Shoulders, in his design of point cathodes for field emission and for what he terms pure field emission (41). However, metallographic analysis of PAGD cathodes (1-4, 74) and the cluster of observed area-dependent effects suggest an altogether different mechanism for the initiation of this low-field discharge, possibly linked to greater buckling of the field at the edges of large area electrodes.

"...the energy accumulated in the second arm of the system consistently and substantially exceeds the energy lost by the first arm."

It is likely that there is some relation between the mechanism responsible for the PAGD regime we have isolated, and its cluster of area-dependent effects, with the electrode area-dependent transient voltage instability of the glow discharge plasma recently reported in low power high-nitrogen/high-helium partial pressure $C0_2$ lasers, albeit that this lasing instability is nonperiodic (84,85). The periodic and current pulse aspects of the PAGD may in fact be what explains these nonperiodic lasing voltage spikes, in that their fortuitous occurrence probably stems from the PAGD threshold voltage-current characteristics: at low input currents, the auto-electronic PAGD emission is a rare event (1-4, 73). At these levels of activity, the deployed reaction forces are minimal or absent. The anomalous PAGD forces are inextricably linked to the intermittent ejection of metal plasma jets (from the PAGD cathode) under optimal conditions of operation in the PAGD regime (the voltage-current characteristic inclusive) and to the *cyclic* plasma instability that develops tremendous field reaction quadratures in the non-stationary vacuum gap.

Given that the relativistic Lorentz force and its classical equivalent, the Biot-Savart Law, can only apply to electrodynamic actions that have reached steady-state, it follows that the PAGD interaction betrays a regime of transient nonuniform current flow in the whole circuit which directly brings force fields into play.

To practically exploit these extraordinary properties of the emission-triggered PAGD regime of plasma discharge, Labofex first developed a series of conversion circuits that led to a very efficient electromechanical coupling, whereby the triggered plasmas could be used to directly generate an inductive motor force from a constant DC supply which is being switched on and off by the autogenous PAGD regime (73, 86). This was the origin of the **Labofex Motor Drive (LMD™)** which utilizes innovative motor principles based upon a total control of the variables affecting PAGD production (applied voltage, applied current, residual gas nature, pressure, electrode area, reactive gap distance, electrode geometry, cathode work-function, etc) (73, 86).

Similar applications would soon follow for transmission of the generated impulses across space, the design of DC inverters and of polyphasic systems (73, 86).

Ultimately, these PAGD-based abnormal cathode reaction forces could be used for the generation of power, if the excess energy that they deployed could be *electronically captured in a system effectively functioning as a power generator*. Conversion of energy by creation of plasma instabilities with energies in excess of breakeven would thus result in the production of power. This is just what we did at Labofex. Utilizing a cathode fuel for the generation of the PAGD regime, we created a simple closed circuit (with isolated circuit segments, where currents are carried by ions and electrons in different parts of the system) in which a physical graft of energy is derived from the plasma triggered by spontaneous cathode emissions in specific reactors. One arm of the closed system performs an entropic operation of loss of energy (this energy is spent in the injection of the pulse generator, to trigger its spontaneous plasma discharge). The pulse output is then captured by a second arm, consisting of excitor, reinverter, filter and storage circuits. On the energy balance sheet, *the energy accumulated in the*

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second arm of the system consistently and substantially exceeds the energy lost by the first arm (5, 87-89). This observation was at the origin of the **XS NRG™ Power Generation System**, an energy converter system for which we have sought extensive patent protection, in the USA, Canada, Israel, and worldwide (87-89). To date, Labofex has filed more than seven patent applications covering this pioneering technology, and at least two other patent applications are presently in preparation.

"It is as if, through the auto-electronic metal/plasma interaction, electricity is directly squeezed out of metals in a vacuum, by virtue of a pulsatory interaction with the polarized vacuum-field."

In accordance with modern treatments of the Law of electrodynamics (22, 76, 90), our invention of the XS NRG™ Power Generation System is made possible by the engraftment of the extraordinarily large PAGD reaction forces transduced by the transient plasma, as an electronic surplus of energy in closed charge systems. To borrow the language of Prigogine (91), these apparently closed systems give rise to self-organizing structures *that are in fact transiently open physical systems, when they elicit anomalous reaction forces under specific conditions of performance*. It is as if, through the auto-electronic metal/plasma interaction, electricity is directly squeezed out of metals in a vacuum, by virtue of a pulsatory interaction with the polarized vacuum-fiel

..."unlike many patents we have discussed above, our patents show explicit and extensive results for the operation of our energy converter system."

Like all known experimental energy-surplus generating processes, such as the thermonuclear fusion process or the Spence machine, energy has to be spent for energy to be generated through the PAGD plasma regime. Unlike any other claim that we know of, for a machine capable of achieving breakeven conditions, the XS NRG™ results are reproduceable and measurable. In other words, these are experimental results and not mere theoretical inferences. In fact, unlike many patents we have discussed above, our patents show explicit and extensive results for the operation of our energy converter system.

The excess energy generated and captured at the output of the XS NRG™ power generation system, under its specific conditions of design and operation, appears to be the result of a catastrophic release of the electronic charge stored in the ejected metal plasma by virtue of its interaction with the field environment of the reactor. In converting the cathode lattice into a metallic plasma, the low-field auto-electronic emission responsible for triggering the PAGD conveys to the plasma jet an excess of charge or energy explosively released from the cathode. Independency from whether the PAGD singularities result from capture of some of the immense reservoir of energy priming the vacuum (22, 92) or from some other unknown mechanism, cathode spot formation involves a net expenditure of the cathhode metal per event, thus defining a process of fuel consumption (4, 71, 93).

According to This conceptualization, the LGEN™ plasma reactor can be considered as *a type of primary battery*, having high specific power and very high energy density values for the cathode fuel (74, 75). However, it is not an electrochemical, but *an electrophysical battery*: its power is stored in the cathode material, and is released cyclically and intermittently by a PAGD plasma autogenously triggered by low-field spontaneous electronic emissions under cold cathode conditions. The *low-field, large gap and large area* polarization of the vacuum plus its depolarization by a fully extinguishable metallic plasma jet erupting from a saturated cathode, are the two self-coupled functions of the PAGD production process that releases energy from She cathhode material. As an electrophysical battery, the LGEN™ reactor is, unlike all known electrochemical batteries (primary or secondary) activable at will, with no recharge requirements.

Labofex has broken new ground in plasma electrodynamics and in electron emissions from metals where no one had expected this to happen. We believe that, with our work in this field, plasma physics has acquired a new, practical and affordable significance for power generation, quite outside of thermonuclear fusion.

More recent developments at Labofex have further broadened the scope of the XS NRG™ technology. The design of improved PAGD reactors (94-95), and of reactors capable of physical commutation of interrupted "vacuum" arc discharges (IVAD) elicited under low-field conditions (88-89, 96), has resulted from this ongoing effort.. Utilization of IVADs in the XS NRG™ Converter System has several mixed advantages: larger input currents are possible (which the voltage-current characteristic of She PAGD precludes) with IVADs than with the PAGD, resulting, under the necessary conditions of operation, in still larger emission catastrophes; separation of the potential switch function from the trigger function (which may be electrodeless), and of both of these from the pulse output function at the collector, permits the utilization of triggered IVADs in LGEN™ or other types of reactors, when these reactors are integrated with the XS NRG™ Converter circuitry (88-89, 97-98).

As we shall refer to in the following chapter, utilization of multireactor XS NRG™ Systems operating in either the PAGD or the IVAD regimes can be coupled to create modular power plants (93, 97) for diverse commercial and industrial applications.

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The Correa Patents

Three U.S. patents have already been granted to Dr. Paulo and Alexandra Correa:

#5,416,391 granted May 16, 1995
#5,449,989 granted Sept. 12, 1995
#5,502,354 granted March 26, 1996

Because of the extreme importance of and careful documentation in these patents, we reproduce, *in full*, the first granted patent, which documents the basic PAGD technology. In this issue of *Infinite Energy*, we also provide a *tiny fraction* of the experimental results documented in the second and third issued patents. *These results, it seems, leave little doubt about the reality of this massively over-unity technology.* In subsequent issues of *IE*, we will provide more results from the Correa patents.

Patent Number: 5,416,391
Date of Patent: May 16, 1995

ELECTROMECHANICAL TRANSDUCTION OF PLASMA PULSES

Inventors: Paulo N. Correa; Alexandra N. Correa, both of 42 Rockview Gardens, Concord, Ontario, Canada, L4K 2J6

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Filed:Oct. 15, 1992

Related U.S. Application Data

Continuation-in-part of Ser. No. 922,863, Jul. 31, 1992, abandoned.

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Field of Search 318/558, 700, 727; 307/106; 313/581; 361/230, 231; 378/122

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ABSTRACT

A direct current power transducer for driving alternating current devices utilizes a discharge tube connected across a current source, the construction of the tube and characteristics of the source being such as to maintain endogenous pulsed abnormal gas discharge within the tube. The tube is capacitatively coupled to an external load including an alternating current device, typically an electric motor. Electric motors of the asynchronous induction or synchronous types are particularly suitable, but other alternating current devices may be used. By adjustments to the current source, the

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capacitance in parallel with the discharge tube, and connections to auxiliary electrodes, the pulse repetition frequency of the discharge may be adjusted, thus allowing variable speed control of types of alternating current motor not normally amenable to such control.

13 Claims, 14 Drawing Sheets

ELECTROMECHANICAL TRANSDUCTION OF PLASMA PULSES

REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of our patent application Ser. No. 07/922,863, filed Jul. 31, 1992, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to a high power gas discharge tube of novel characteristics, and to applications of the tube in the control of electric motors and other alternating current devices.
2. Review of the Art
As the current passed through a gas discharge tube is increased beyond the levels at which normal glow discharge takes place, such normal gas discharge being characterized by a negative resistance characteristic leading to decreasing potential between the cathode and anode electrodes of the tube, a region of abnormal glow discharge is entered in which the negative resistance characteristic changes to a positive resistance characteristic leading to increasing potential between the electrodes. Typically this increased potential rapidly leads to breakdown into vacuum arc discharge between the electrodes, again characterized by a negative resistance characteristic. Accordingly, gas discharge tubes have been operated in the normal glow discharge or vacuum arc regimes in which stable operation can be achieved by suitable ballasting of the tube, the former regime being suitable for low current applications and the latter for high current. It is possible to utilize a normal glow discharge tube in a low frequency oscillator circuit by placing capacitance in parallel with the tube and in series with the ballast because such a tube is characterized by a comparatively high striking potential at which discharge is initiated, and a lower but still high extinction potential at which discharge ceases. Operation in such a mode with vacuum arc devices is difficult because, in order to turn off the device effectively, the arc must be extinguished or otherwise interrupted or divested for long enough to disperse the intense ionization formed in its path.

Devices operating in the vacuum arc regime have other problems, particularly in terms of ensuring adequate electrode life, which have led to gas diodes and triodes (thyratrons) being superseded by semiconductor devices in most applications. A further limitation of such devices is that the great difficulty in turning them off, except by terminating current flow through the device for a finite period, limits their usefulness as control devices to rectification, current turn-on and low frequency alternating current applications.

The only prior art of which we are aware which successfully exploits the abnormal glow discharge regime is the process described in U.S. Pat. No. 3,471,316 (Manuel) issued Oct. 7, 1969, which we understand is commercially utilized in forming organic coatings on metal cans. It relies on the application of externally generated current pulses to force a discharge tube temporarily into the abnormal glow discharge region, the pulses being sufficiently short that no vacuum arc is established. There is no disclosure of any endogenous pulsed abnormal glow discharge, the apparatus is dependent upon an external pulse generator to operate, and its utility is completely different from the present invention because it uses externally generated pulses rather than generating such pulses.

We are also aware that the use of vacuum arc discharge tubes has been proposed for the control of inverters, as exemplified by U.S. Pat. No. 4,194,239 (Jayaram et al), which discloses the use of vacuum arc discharge tubes in which the discharge is steered magnetically between multiple electrodes to provide a commutating effect. Such an arrangement acknowledges the difficulty of extinguishing a vacuum arc, and seeks to overcome the difficulty by instead switching the discharge between electrodes by the use of externally applied magnetic fields.

SUMMARY OF THE INVENTION

The problems associated with the operation of vacuum arc devices are typically associated with the establishment of a continuous channel of low resistance ionized plasma between the electrodes of a device operating in this mode, typically accompanied by intense heating of the electrodes. Such a channel is difficult to interrupt in rapid and predictable manner once established. The pulsed abnormal glow discharge regime is characterized by no such continuous channel having been established, and predominantly cold-cathode auto-electronic emission rather than thermionic emission, these characteristics provide the ability to extinguish the discharge readily.

We have found that, by suitable design of a low pressure gas discharge tube, we can sufficiently inhibit transition from the abnormal glow discharge regime into the vacuum arc discharge regime that we can successfully exploit characteristics of the abnormal glow discharge regime to provide a device having valuable and controllable characteristics as a high power, pulse generator when fed from a current source. Such a pulse generator has useful applications in for example motor control and other applications requiring high current pulses. It is a valuable characteristic that the pulse repetition frequency can be varied over a range, the extent of which itself varies according to the physical characteristics of the tube and the environment in which it is operated. According to circumstances, the frequency may range as low as 10 pulses per second or range as high as 10^4 pulses, these figures being exemplary only and not limitative.

The purpose of the present invention is to provide a means to operate alternating current machines, and in particular to derive useful electromechanical work from any vacuum discharge tube capable of sustaining a stable pulsed abnormal glow discharge (PAGD). The present invention provides a simple circuit having at least two parallel arms: a pulse generator arm containing the vacuum discharge and an electromechanical arm which transduces electrical pulses into mechanical energy. In the latter, the electromechanical device is integrated into a reactive load presenting a capacitance in parallel with the tube. The present invention was specially devised to work with specific cold cathode vacuum tube pulse generators as disclosed in the parent application, using either diode or triode connections, but the circuitry can be made to work with any suitable vacuum device capable of being operated in an endogenous pulsed abnormal glow discharge regime under cold cathode conditions.

The advantage of using a spontaneous emission self-pulsing device such as that described in the parent application lies in the fact that the speed of an AC motor and its torque can be varied directly by altering any of the parameters that affect pulse frequency as described in that application. Two of these parameters, parallel capacitance and applied, constant direct current, are of particular usefulness, since when all other parameters are the same, the rate of pulsed abnormal glow discharge, controlling motor speed and torque, can be made to vary as a function of increasing current applied to the cold cathode device, for any given discharge capacitance employed. This yields an extremely simple method of motor speed control, particularly suited to drive synchronous and induction AC motors from a starting DC supply, but also generally applicable to any motor, whether rotary or linear, whose speed or rate is dependent upon the frequency of a pulsed or alternating current. Rather than placing an alternating current machine directly in the circuit containing the discharge tube, it may be connected indirectly through a transformer or synchro-transmitter system.

SHORT DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph illustrating the current to voltage relationship exhibited by a notional vacuum discharge tube;
FIG. 2 is a graph illustrating the current to breakdown, extinction (PAGD) and sustaining (VAD) voltages of a particular vacuum discharge tube;
FIG. 3 is a circuit diagram of a first embodiment of the invention, using a single phase permanent-split induction or synchronous capacitor motor connected in parallel with a pulse generator using a vacuum discharge tube configured either as a diode or as a triode;
FIG. 4 is a circuit diagram of a second embodiment, employing two motors in series, and a triode connected vacuum tube pulse generator;
FIG. 5 is a circuit diagram of a third embodiment, employing two motors in series, and two vacuum discharge tubes placed in series;
FIG. 6 is a circuit diagram of a fourth embodiment, employing a two-phase motor, and two vacuum discharge tubes placed in series;
FIG. 7 is a graph illustrating the results of tests using the first embodiment of the invention, using a permanent split capacitor induction motor, showing how motor speed in RPM varies with the total series value of the external capacitance placed in parallel with the vacuum discharge tube by the electromechanical arm of the circuit;
FIG. 8 is a graph illustrating the synchronous RPM vs. pulses per second linear response, in the circuit of FIG. 3, of a single phase, synchronous hysteresis capacitor motor for four different series capacitance values in the electromechanical arm of the circuit and the maximum pulse rates obtained for each combination;
FIG. 9 is a graph showing the rotor blocked torque, measured by a rope and pulley method, of a single phase, synchronous hysteresis capacitor motor in the circuit of FIG. 3, as a function of the increasing direct current input resulting in increased pulse rate; 4
FIG. 10 is a graph showing the rotor blocked torque, measured by a rope and pulley method, of a single phase, synchronous hysteresis capacitor motor both in the circuit of FIG. 3 (as a function of increasing PAGD rate due to the increasing direct current applied to the circuit), and when run at AC line frequency of 60 Hz, torque being shown in each case as a function of the rms volts at the motor input;
FIG. 11 is a graph exemplifying how the pulse frequency of a PAGD discharge is related to direct current applied to the tube in the circuit of FIG. 1, accompanied by curves showing the potential applied to the tube and the power in watts drawn by the tube;
FIG. 12 is a graph exemplifying variation in RPM, rms current drawn, input volts, and true and apparent power (watts and volt-amperes) of a synchronous motor in the circuit of FIG. 1, and under the conditions of FIG. 9;
FIG. 13 is a graph showing the rms volts per pulse per second at various pulse rates for two different single phase capacitor motors (induction and hysteresis) utilized in the circuit of FIG. 1;
FIGS. 14 and 15 illustrate two configurations of inverter according to the invention which may be utilized to drive alternating current devices through a transformer;
FIG. 16 shows in simplified form a variant of the circuit of FIG. 3 in which the discharge tube is connected differently;
FIG. 17 shows a variant of the circuit of FIG. 3 in which the electromechanical arm is a synchro-transmission system.
FIG. 18 illustrates a pulse generator having a glass housing and tetrode geometry;
FIGS. I9a and I9b illustrate central cross sections of the pulse generator of FIG. 18, and a modification thereof, respectively;
FIG. 20 illustrates a Fowler-Nordheim plot of the Vx or Vs values for the PAGD and VAD regimes, respectively, in a pulse generator excited with a positive-polarity constant voltage DC power supply, the PAGD and VAD values being shown respectively in closed and open squares;
FIG. 21 illustrates a continuous variation of NGD sustaining /PAGD extinction voltages (Vs/Vx), from breakdown to glow extinction, with decreasing pressure (at a rotary pump), in 4 pulse generators having different plate areas but the same electrode material (H34 aluminum), the same gap distance and the same potential of 860 VDC prior to breakdown;
FIG. 22 illustrates a continuous variation of PAGD frequency with decreasing gas pressure in 3 pulse generators having different anode and cathode plate areas (16, 64, 128 cm2) but the same cathode material (H34 aluminum) and the same gap distance of 5.5 cm;
FIG. 23 illustrates a shift of the PAGD regime to higher pressure regions during pumpdown with a rotary vacuum pump in an argon atmosphere;
FIG. 24A illustrates the circuit used in the tests that supplied data for FIGS. 2 and 20 to 23; FIG. 24B illustrates the circuit used for test results described in Example 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following detailed description, the same reference numbers are used to denote identical elements present in more than one Figure.

The context of the invention in terms of vacuum discharge phenomena will first be discussed with reference to FIGS. 1 and 2. Referring to FIG. 1, which plots the potential between the principal electrodes of a vacuum discharge tube with increasing current, potential being shown on a linear but arbitrary scale of voltage, and current on a logarithmic scale in amperes, curve A, below its intersection with curve B. represents a typical relationship between current and voltage for cold cathode discharges, including auto-electronic emissions, whilst curve B represents a typical relationship for thermionic glow discharges, including thermionic emissions. The high-current intersection of the two curves at point E represents a transition into the vacuum arc discharge (VAD) region (curve C) with the establishment of a continuous low resistance plasma channel between the electrodes.

It will be noted that curve A exhibits, with increasing current from very low levels, an initially rising voltage or "positive resistance" characteristic, through the Townsend discharge (TD) region, a flat characteristic through the constant discharge (CD) region, a falling voltage or "negative resistance" characteristic through the transitional region discharge (TRD) and normal glow discharge (NGD) regions, to a minimum, before once again ris-

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ing to a peak of F and then falling to an even lower minimum, equal to the sustaining voltage for a vacuum arc discharge, through the abnormal glow, discharge (AGD) region. The rising potential over the first portion of the AGD region is believed occasioned by saturation of the electrodes by the glow discharge, which causes the potential to rise until autoelectronic emission sets in allowing the potential to fall again as the current rises further. In practice, the increasing interelectrode potential following saturation, and other factors such as electrode heating, leading to thermionic emission, will tend in conventional tubes to result in a premature transition from the AGD into the VAD, regime, following a curve similar to curve D shown in FIG. 1.

The present invention relies on the use of gas discharge tubes designed to avoid premature transition from the AGD to the VAD regimes, and capable of being operated in a stable manner in that region of the characteristic curve of FIG. 1 extending between points E and F. Referring now to FIG. 2, which plots test results for just such a tube, constructed as described below with reference to FIG. 18 and 19, and shows, again on similar coordinates to FIG. 1 (except that the potential units are defined), the extinction or sustaining potentials of the tube (the same information as plotted in FIG. 1), together with the breakdown potential (i.e. the potential required to initiate the auto-electronic discharge). It will be noted that the breakdown curve shows two discontinuous portions X and Y. corresponding to the vacuum arc and abnormal glow discharge regimes respectively. The intersection of curve X, and curve Z representing the sustaining or extinction potential is illustrative of the difficulties inherent in extinguishing a vacuum arc discharge, since a decrease in current is accompanied by a decrease in breakdown voltage until it equals the VAD sustaining voltage which does not vary greatly in this region. On the other hand, the combination of a fairly high and constant breakdown voltage (curve Y) combined with an extinction potential which rises with decreasing current in the region E-F (see FIG. 1) of the pulsed abnormal glow discharge regime means that the pulsed abnormal glow discharge will be extinguished if the current source during the tube operation ceases to be able to sustain the increasing current required to maintain the discharge as the potential between its electrodes drops, at some current below the intersection of curves X and Z.

If the effective internal resistance of the source is above some critical level, then as the current through the tube rises, the proportion of the source potential developed aross the tube will fall until it intersects the curve Z at a current below the intersection with curve X, at which point the abnormal glow discharge will self extinguish, and the current flow through the tube will drop abruptly until the current through the tube combined with the potential between its electrodes again intersects the curve A in FIG. 1. This permits reestablishment of a rising current through the tube traversing the abnormal glow discharge region as the potential across the tube rises to the peak F and then again falls to a point short of E. Accordingly, under these circumstances, a pulsed abnormal glow discharge will be exhibited, accompanied by high amplitude current pulses through the tube. It should be understood that the curves of FIG. 1 are indicative of the static behaviour of a nominal discharge tube under particular current and voltage conditions, and are not fully indicative of the behaviour of the tube under dynamic conditions in which tube current and inter-electrode potential vary with time, nor with changes of the many other factors which may influence tube behaviour. In particular, the plasma effects generated in various phases of tube operation require finite time to form, reform or dissipate as the case may be, and in the case presently under consideration this time factor, combined with time constants of the external circuit in which the tube is placed, are determinative of the pulse frequency of the discharge.

The definition of any regime of electrical discharge in a vacuum is usually presented as dependent upon the major operational parameter being considered, i.e. upon the variation of direct current passing between the primary electrodes. For a given optimal vacuum (which must necessarily be less than perfect) all gas electrical discharge regimes can be presented as dependent upon this parameter. FIG. 1 is such a presentation and the peak that characterizes the abnormal discharge region means that within this region, as the applied current is increased linearly, the resistance of the vacuous medium in the tube first increases with increasing current, only to subsequently decrease, still with increasing applied current, down to the minimum resistance value corresponding to the sustaining potential of a "vacuum" arc (which is somewhat above the ionization potential of the gas, or in fact of the metal vapour, in the enclosure). As the transition from a normal glow discharge into a vacuum arc discharge is made either directly (in thermionic devices) or indirectly, in cold-cathode conditions, via an abnormal glow discharge that may be more or less precipitous, it is only in the ideal diode and the ideal vacuum that both linear functions (corresponding to the regimes that have a sustaining potential) and nonlinear functions (corresponding to the transition regions, such as the TRD and the AGD) appear to depend exclusively upon the input current. In fact, many factors affect the AGD, foremost amongst them, pressure, plate distance and plate area. Hence the peak in the curve of FIG. 1 is an idealized view of events.

This said, we are left with the experimental observations and what they tell us. In this respect, auto-electronic emissions characteristic of the pulsed abnormal gas discharge (PAGD) regime can be seen to emerge from the NGD, as the current is increased beyond the point when the cathode glow has reached plate saturation (if the current is not too low and the plate area not too large).

The same effect occurs when the pressure is reduced and the current is kept constant at a suitable level (neither too high nor too low, exact figures depending on other factors such as gap distance and plate area, etc.).

If the current is increased further, in either case, the PAGD regime fully emerges (in other words, in pumpdown tests, the applied current also has to be sufficient). In this regime the plate is not so much saturated with a negative glow (which remains, but is attenuated), but exhibits local concentrations of the plasma that arise in a given area of the cathode as a function of the autoelectronic emission mechanism. If the applied current is increased in steps, a stage is reached at which the extinction potential of the PAGD falls until it meets the minimum potential of an arc discharge, as demonstrated in FIG. 2. With reference to FIG. 1, this means that the current-dependent variation of the PAGD in these devices passes from a high to a low extinction potential or from a high to a low electrical resistivity of the medium, and is thus localized on the descending slope of the peak in FIG. 1. Expressed in terms of resistance characteristics, the regime of the pulsed abnormal glow discharge; spans, as a function of applied current, a subregion in which a positive resistance characteristic changes into a leading negative resistance characteristic. The pulsed regime of the AGD is only sustainable when the intensity of the applied current is greater than that needed to rapidly saturate the plates (but not so great as to set up VAD), the result being development of auto-electronic emission with its associated inverted cone-like discharge and a residual, faint glow of the entire cathode (rather than a saturated NGD).

Each PAGD cycle begins as a singular emission and performs a cycle of functions whose electrical characteristics vary accordingly with time. During a charging process (which eventually leads to emission), the plate potential rises to a maximum at F (see FIG. 1), while being limited by the maximum virtual value of the applied current. Any substantial increase in the applied current is blocked by the insulating properties of the intervening medium (as if a very large resistance characterized the device), in the discharge process, beginning with the initiation of auto-electronic emission at F, conditions for conduction across the (operational) vacuum are established and, as a consequence, the resistance characteristic of the device becomes increasingly negative until the extinction potential is reached, at which point the glow discharge ceases. This endogenous on/off behaviour is exactly what characterizes the PAGD cycle.

Two boundary conditions arise. In the first case, the available current is not quite enough to sustain the PAGD. In this instance, full escape from the NGD regime and the characteristics associated with its sustaining potential will not occur, while any heating of the cathode will eventually lead to the establishment of a semi-thermionic cathode glow. In the second instance, there is a risk of degeneration into a thermionic NGD or a VAD if the available current is too high or sustained too long. This degeneration will set in during the second phase of the PAGD unit cycle, and may lower the resistance of the device to the point of constant conduction of current across the vacuum; the result is that the auto-electronic emission is not quenched, as spontaneously happens in the PAGD. Thereafter, extinction of the resulting VAD, which may be promoted by a variety of factors is an unpredictable event; if the current is available, the arc will burn for as long as there is energy supplied and as long as there is cathode material available to consume. A VAD in no way resembles a regular, cyclic oscillator, which is the outstanding aspect of the PAGD. Whilst an arc discharge is, like the PAGD, an auto-electronic emission phenomenon characterized by intermittences (the apparent constancy of an arc is the result of the high frequency of these intermittences), such an arc does not exhibit the regular or quasi-regular cyclical nature of the PAGD, nor its inherent current limiting characteristics.

In order that a stable pulsed abnormal glow discharge (PAGD) as discussed above may be obtained, the discharge to be utilized must be capable of repeated excursions into the region E to F of FIG. 1. This entails that the tube be constructed so that, as the tube operates and the current through it rises, the potential across the tube can reach the peak F in FIG. 1 and beyond, without the abnormal glow discharge degenerating into a vacuum arc discharge. This will be influenced, among other factors, by the extent of thermionic emission from the cathode which will itself be influenced by resistive heating of the electrodes and their work function, as well as by their separation and configuration, and the nature and pressure of gas within the tube, as well as the presence of auxiliary electrodes or probes. The influence of these various factors is extensively exemplified below, with reference to the description associated with FIGS. 18 to 24b, which description; discloses tubes capable of sustaining PAGD. Whilst the present invention is described with reference to its use in connection with such tubes, it should be understood that the invention may be implemented utilizing any tube capable of sustaining a stable PAGD discharge whether or not disclosed in our earlier application.

FIG. 3 shows a first exemplary embodiment of the invention operating in the examples described with a single phase permanent-split induction or synchronous capacitor motor having a rotor R. stator windings **15** and **16**, and a capacitor **17**. The motor is connected to terminals **13a** and **13e** and via capacitors **10** and **11** to the electrodes of a vacuum discharge tube **7**, capable of producing cold cathode abnormal glow plasma pulses and constructed in accordance with the principles set forth in FIG. 18 to 24b and their associated description. Motors with other characteristics, such as single phase capacitor-start induction motors, two-value (start and run) capacitor induction motors, repulsion-induction motors, repulsion-start induction-run motors, reluctance motors, universal motors, split phase motors, two-phase induction or synchronous motors (wired as single phase capacitor-run motors), or single phase rotor input synchro-transformer generators could also be connected to the same terminals **13a** and **13a**

As shown in FIG. 3, the voltage source may be either a line-fed DC power supply **1** (preferably constant current), a DC generator **2** or a battery pack **3**. For best results, one of the latter two should be employed because line-fed supplies will contain other parallel circuitry, induding an internal bypass capacitance and, unless they are very well regulated, will leak alternating current from the line which may influence the pulse rate or stability of the PAGD discharge. The supply voltage and current may be controlled by using methods known to those skilled in the art, whichever source is used. With line fed power supplies it is preferred to control the DC output by varying the power input using the autotransformer method. With a DC generator, the power output can be controlled directly by varying the speed of the generator. With a battery, simple control of input direct current and output pulse frequency from vacuum device **7** is best achieved with a variable series resistor **4**. Diodes **5** and **6** prevent transients from the pulse discharge from reaching the DC source.

The discharge tube **7** is shown in FIG. 3 connected in a diode configuration with cathode **8** placed between rectifier **5** and capacitor **10** and the anode **9** placed between rectifier **6** and capacitor **11**, by virtue of a switch **22** being turned off (position NC). When switch **22** is turned to position **13a'** so that an axial member or probe **12** within the tube is connected to the terminal **13a**, the pulse frequency increases by an amount depending on the parameters of the circuit as a whole. In this configuration, the axial member of the pulse generator functions as a plasma excitor member, as it lowers the potential and increases the rate of discharge by adding its spontaneous emissions to those of the cathode. The same result obtains when switch **22** connects axial member **12** to position **13e'** instead, thus joining it to terminal **13e**.

The capacitors **10** and **11** are placed in parallel with the reactive electrodes, with the motor **14** in series between capacitors **10** and **11**, but in parallel with either the plates (diode configuration) or the axial member and the cathode or anode (triode configurations) as the case may be. For best results, it is desirable to have capacitances **10** and **11** disposed symmetrically in the circuit as shown in FIG. 3. An unbalanced circuit results when one capacitor is absent, and anode counter-emissions become frequent. Capacitance values for discharge capacitors **10** and **11** are determined as a function of the type of vacuum pulse device employed and the nature and performance characteristics of the AC motor **14** chosen. If the capacitances are too small, the motor will not start nor maintain rotation; if too large, the motor win not turn smoothly or continuously, and spontaneous anode counter-emissions may occur which will break the rotation of the motor by reversing the direction of the electromagnetic flux. The critical parameter is the total series value of the capacitance placed in parallel with the pulse generating device, and there is no need for the capacitances **10** and **11** to be identical; in fact it is preferred that there be a higher capacitance on the side of the cathode (capacitance **10**) than on the anode side (capacitance **11**) when the triode configuration has the axial excitor member connected to **13a** via switch **22** at position **13a**: or the reverse when the axial member is connected to **13e**.

The AC motor employed may, in general, be of any type. Split phase, single phase, or two phase AC motors, be they universal, induction or synchronous types, having squirrel-cage, wound-type, eddy current, drag cup or hysteresis-type rotors, will all respond to the pulses generated in this circuit. Single phase, permanent-split capacitor, AC induction motors having squirrel-cage rotors and single phase AC synchronous hysteresis capacitor motors are preferred. The latter, in particular, have the advantage of developing a nearly uniform torque from stationary or blocked rotor positions to synchronous speed as well as producing a smoother response to the pulsating nature of single phase power (e.g. in a 60 Hz circuit, power is in fact delivered in pulses at 120 Hz) than that of other single phase motors. The motor **14** in FIG. 3 has its main winding coil **15** in parallel with the discharge tube and an auxiliary coil **16** connected in parallel with the main coil **15** via the phase capacitor **17**. This corresponds to the connection as a single phase AC permanent-split capacitor motor. To reverse the direction of the motor it is sufficient to switch the position of switch **18** from pole **19** to pole **20**. If motor **14** were a suitable two phase AC induction or synchronous motor wired as a permanent-split capacitor single phase motor, then the reversal obtained by switching **18** would provide an equal torque in either direction of rotor rotation of the motor. A less efficient start-up or phase displacement utilizes a resistance in place of capacitor **17**, in a manner known in the art. The resistance may be varied to alter the motor speed.

Replacement of pulse generator **7** by a suitable vacuum device, as diverse as a fluorescent light bulb (as a diode) or a deuterium triode indicates that, despite the absence of desirable physical parameters identified in the parent application, any cold cathode operated vacuum tube device capable of endogenous pulsed abnormal glow discharges through spontaneous auto-

electronic cathode emissions when operated in the abnormal glow discharge region, is capable of serving as the pulse-forming discharge tube in the circuit. By contrast, whilst discharge tubes operating in the normal glow discharge region can be used to form pulse generators, the mechanism is different and the power output would generally be too low to be useful in an electromechanical application.

Any inductive AC electromechanical device such as a relay solenoid or linear motor, may also be employed in place of motor **14** at terminals **13a** and **13e**, FIG. 3, to derive electromechanical work from the on and off switching action of the vacuum discharge tube **7** when operated in the abnormal glow discharge region.

An advantage of the invention is that a constant current supply coupled to a suitable vacuum discharge tube can be used to obtain smooth rotary action from certain AC motors in an easily controllable fashion, without having recourse to a conventional inverter system in order to produce alternating current, and provides a simple means of frequency control. Whereas the main limitation imposed on the use of induction or synchronous AC motors is that they are essentially constant speed motors which can only vary their torque as a function of the magnitude of the AC voltage and current input (given that the frequency of the power supply cannot normally be changed), the present invention allows the torque and speed of an AC motor to be controlled by varying the DC voltage and current applied to any cold cathode vacuum device **7** operated in the pulsed abnormal glow discharge regime as discussed above, as well as by varying the pulse rate of the vacuum discharge by other means such as through the probe **12** in a device as described in the parent application. Furthermore, the electromechanical force is developed from a nearly even sequence of discontinuous energy bursts, of controllable frequency, rather than continuous sinusoidal power pulses at a fixed frequency.

FIG. 4 shows how two single phase permanent-split capacitor AC motors **14a** and **14b** may be connected symmetrically in tandem, both placed in paraUel with a single vacuum discharge tube **7**, following the principles described above for FIG. 3. Independently of whether the axial member **12** is or is not connected to junction **13b**, a capacitor **21** may be advantageously introduced between junctions **13b** and junction **13c**, to even out the rotation of the two motors, although it is not essential.

FIG. 5 shows how two (or more) discharge tubes may be connected in series to drive two or more motors **14a** and **14b** also in tandem, from the output of two or more vacuum devices **7** placed in series with each other. Connections **13a'** and **13d'** from axial members **12a** and **12b**, as well as capacitor **11** and its connection to **13b** may be omitted and the circuit will still function. The circuit of FIG. 5 will produce a pulse sequence at the output from the second tube which is phase shifted with respect to that of the first tube, with further shifting as more tubes are added. It is thus possible to couple multiphase motors as shown in FIG. 6, (showing a two phase motor) with a suitable capacitance **21** being introduced between junction **13b** and junction **13c** to control further the firing rate of the second vacuum device **7b**. The addition of more tubes in series will further displace the phase of the pulse sequences in each successive device. Sufficient relative angular displacement of two tube-generated pulse sequences can also be achieved by introducing a suitable delay relay between points **23** and **24**, at the cathode input to the second vacuum device.

In general, the pulse frequency developed by a discharge tube operated to produce PAGD in the circuits described will depend on several factors: some are circuit factors, such as the total discharge capacitance placed in parallel with the vacuum device, and the characteristics of the power supply (direct current and voltage values); others are physical factors, such as the pressure, the chemical nature of the gas fill and the a field-emission work function of the cathode material and its composition and still others are geometrical or dimensional in nature, such as the interelectrode distance, the plate area and the parallel plate arrangement. All these factors are discussed in the parent application.

The following examples relate to tests of the circuit of FIG. 3.

EXAMPLE 1

The circuit of FIG. 3 was tested with a single phase squirrel cage induction motor, the capacitor **17** being 2 μFd. The RPM of the rotor was measured with a stroboscopic tachometer to determine how it varied with the total series value of the external capacitances **10** and **11** (FIG. 3) placed in the electromechanical arm of the circuit, in parallel with the anode and the cathode of a discharge tube constructed as described with reference to FIG. 18, with 64 cm2 plate area, 5.5 cm interelectrode distance and an air fill at 2 Torr. The tube was excited in a triode configuration (switch **22** at position **13a'** and switch 18 at position **19**, FIG. 3) by an AC line-fed DC power supply. The results are shown in FIG. 7. Provided that the capacitance is not too high or too low, other factors such as the frequency of the pulses generated by the vacuum device (which increases with decreasing parallel capacitance) and the type and characteristics of the windings and of the rotor of the motor employed, have a greater influence on the motor speed.

EXAMPLE 2

The total value (internal to the power supply and external to it) of the capacitance placed in parallel with the discharge tube in the same triode configuration of the previous Example, in turn affects the maximum frequency of abnormal glow discharge pulses produced, and the effective synchronous motor RPM, as shown in FIG. 8. This figure presents motor RPM as a function of the total series value of the external capacitances placed in the electromechanical arm of the circuit, and shows results obtained with a single phase hysteresis capacitor motor (rated as 110 VAC 1/10 Hp. with the auxiliary winding motor capacitance **17** having a value of 2.4 microfarad). These tests indicate that for any given AC motor there will be optimal values for the pulse rate produced by the discharge tube, and that this pulse rate will have a maximum value for any particular value of the total capacitance placed in parallel with the pulse generator, and specifically in the electromechanical arm of the circuit, and this capacitance itself will have an optimal value. Conversely, for any given motor characteristics, a pulse generator can be designed with optimized circuit or electrical, physical and geometrical parameters.

EXAMPLE 3

With a rope-and-pulley type of torque meter, the rotor-blocked torque developed by a synchronous hysteresis motor was tested using the circuit of FIG. 3, and the same vacuum device as the previous two Examples. This type of motor was chosen because in an "ideal hysteresis" motor, the torque developed is constant at all speeds from standstill to synchronicity, locked rotor, pull-in and pull-out torques being identical. Even though a single-phase capacitor-type hysteresis motor departs more from the ideal curve than a polyphase hysteresis motor does, on account of the elliptically shaped rotating fields set up by a capacitor motor, most manufacturers make permanent-split capacitor single phase hysteresis motors with identical full-load and locked rotor torques. We have utilized one such motor for our tests. FIG. 9 illustrates the range and mean of at least nine tests conducted at each of three different input direct currents into the pulse generator, the extinction voltage remaining relatively constant at about 330 VDC, with the results expressed as standstill torque developed related to the pulse rate of the pulse generator. The discharge tube was triode connected as described with reference to FIG. 3, and the total series value of the external parallel capacitance to the pulse generator was 36.6 microfarads. It is readily apparent that the torque developed is proportional to the pulse frequency as is desirable for the purposes of the present invention. The torque developed is also proportional to the voltage input into the motor (i.e. the tube output voltage) as is exemplified in FIG. 10, where tests of the PAGD-induced torque (closed squares) obtained and measured under the same conditions described for FIG. 10, over the frequency range of 11 to 45 PPS, are compared with tests of an AC 60 Hz line sine wave generated torque (shaded circles), as a function of the input volts into the motor from each source.

EXAMPLE 4

An example of the relationship of operational parameters involved in the performance of the circuit of FIG. 3 is shown in FIGS. 11 and 12, using the same pulse generator device employed in the previous Examples 1 through 3 at an air pressure of 1.75 Torr, and using the same hysteresis motor as described in the previous Examples 2 and 3. The tests of FIGS. 11 and 12 utilized a total series capacitance for the external electromechanical arm of 7.9 μfd (with reference to FIG. 3: capacitor **10**=440 μfd, capacitor **11**=8 μfd)). The same triode circuit was employed as in previous examples. FIG. 11 illustrates how the discharge rate of the pulse generator is controlled by the steep increase in applied DC amperes (open squares) while DC volts (closed squares) decrease to a near plateau as the pulse frequency reaches 40 pulse per second. Total wattage input to the discharge tube in the PAGD regime, at the output from the transformer secondary of the DC power supply, is shown in shaded squares. FIG. 12 shows the corresponding pulse output from the vacuum tube into the motor arm of the circuit and illustrates how the AC rms current (open squares), the AC rms voltage (open circles), the true and apparent power (respectively, closed and shaded circles) as well as the rpm of the synchronous hysteresis motor increase proportionately to the discharge rate of the pulse generator. With reference to FIG. 3, the effect of the connection to the axial member **12** through the switch **22** is to promote, other conditions being equal, an increase in discharge frequency: at these tube input and output parameters changing from a diode to a triode configuration typically increases the maximum discharge rate from 30 to 43-45 PPS.

With the triode configuration and an other conditions being unchanged, the effect of a larger total series capacitance value placed in parallel with the pulse generator, in the electromechanical arm of the circuit, is to limit the maximum pulse rate of the PAGD and the related motor parameters, as illustrated by FIG. 8.

EXAMPLE 5

When a motor is wired as a single phase motor and connected to an adjustable frequency power source, the voltage applied to the motor stator terminals should change proportionately to the change in frequency in order to maintain the constant air-gap flux that permits the motor to develop its rated torque over its speed range. A provision is thus desirably made in the power source not only to maintain a volts to pulse rate relationship which is relatively constant over an operating range, but also to maintain it at a value suited to the motor. In the present invention this is easily accomplished by adjusting the total series capacitance in the electromechanical arm of the circuit to the set value of the operating motor for any given input frequency range. Two such examples of volts per pulse per second curves as a function of PAGD frequency at the motor input are shown in FIG. 13, one (shaded circles) obtained with a squirrel cage induction motor (110 VAC, 1/20 Hp. 2 μfd auxiliary winding capacitance) and the other (open circles) with the same hysteresis motor used in the previous Examples 2 through 4. Total series capacitance values for the parallel electromechanical arm of the circuit were respectively 3 and 8 mfd. In both instances shown, the volts per cycle value tends to become a constant with increasing frequency, reaching a plateau at around 25 PPS. In some instances, it may be appropriate to incorporate a discharge tube operating in the PAGD regime in an inverter circuit so that the pulse output may be utilized by a remotely located alternating current device. The intermittency of the pulses produced by the arrangements described above are not conducive to efficient operation of conventional transformers, and a push-pull circuit arrangement is preferred. While such an arrangement could utilize two discharge tubes, an advantageous arrangement utilizes a single tube of the type described in the parent application, as shown in FIG. 14. In this instance, both plates **8a** and **8b** of the tube act as cathodes and are connected to the diode **5**, and the probe or auxiliary electrode, which is typically of tungsten, acts as a common anode **9** and is connected to the diode **6**. The capacitors **10a** and **10b** are connected to opposite ends of a centre-tapped primary winding of a transformer **26**, providing an alternating circuit output through a secondary winding. The centre-tap of the primary winding is connected to the electrode **9**. The two halves of the primary winding inductively couple the cathode circuits in antiphase, thus synchronising the PAGD pulse trains involving the two cathodes in antiphase.

In a modification of the circuit shown in FIG. 15, the capacitors 10a and 10b are connected directly to the electrode **9**, and the primary of the transformer **26** is connected directly between the two cathodes with its centre tap connected to the diode **5**. Whilst this arrangement bears some superficial resemblance to known inverter circuits employing VAD devices, it should be noted that the circuit is completely self-commutating, and does not need moving external magnetic fields to provide commutation as in the prior art.

It should be understood that, using a suitable three or more phase transformer, and a vacuum discharge tube with three or more cathodes (or three or more discharge tubes), a higher pulse rate or a multiphase output may be obtained from the transformer. It should also be understood that, as shown in FIG. 16, in some applications it may be advantageous to strap the plates **8a** and **8b** in parallel as cathodes **8a** and **8b** and use the auxiliary electrode as an anode **9**, in a circuit similar to that shown in FIG. 3, the tube being operated either in diode mode as shown, or in triode mode utilizing an additional auxiliary electrode.

FIG. 17 shows a modification of the circuit of FIG. 3. When the switch at node **13a** is in position **25**, it provides pulses only to the rotor **R2** of a self-synchronous (selsyn) unit **27** in a synchro-transmitter system, in which a three phase output of the unit **27** is utilized per se, or transmitted to three phase windings of a second, slave unit **28**, the windings of whose rotor **R3** is closed through an external short circuit or load. Whilst rotation of the rotor **R2** will provide synchronous rotation of the rotor **R3** in well-known fashion, it may be advantageous to place the switch in position **24** to connect the motor **14**, and to link its rotor **R1** to the rotor **R2** to provide this rotation, thus in turn providing remotely a corresponding rotation of rotor **R3**.

FIGS. 18, 19a and 19b of the drawings illustrate the construction geometry of discharge tubes which may be utilized as pulse generators such as shown in FIGS. 24a and 24b and in implementing the invention. The discharge tubes are assembled using accepted techniques which are well known to those skilled in the art of vacuum tube technology.

FIG. 18 shows a pulse generator, generally referred to by reference **50**, having a cylindrical housing **52** which is preferably a glass material. Depending on the interelectrode spacing of the pulse generator, which in accordance with the invention may range from about 3 cm to about 20 cm or more, the glass housing **52** is preferably Pyrex™ or #7740 borosilicate (Corning, N.Y.). Such cylindrical housings **52** are commonly available in diameters of about 6 to about 11 cm and a variable thickness of about 0.2 to about 0.3 cm. Other borosilicate glass, quartz glass or ceramic housings can be employed as suitable alternatives to Pyrex glass and in sizes outside these commonly available ranges.

The pulse generator 50 further includes two parallel, spaced-apart electrodes comprising a cathode **54** and an anode **56**, hereinafter often collectively referred to as "plates" for brevity and convenience. As noted above, the anode and cathode in pulse generators according to the invention are spaced 3 to 20 cm or more apart. The cathode **54** and the anode **56** may be either flat or curved and are preferably made of 0.5 to 2.0 mm thick aluminum, nickel or nickel alloy. The thickness of the cathode **54** and the anode **56** is not critical and any thickness within a reasonable range apparent to those skilled in the art may be used. The surface areas of the cathode **54** and the anode **56** are preferably quite large in comparison to the surface area of an

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anode/cathode in prior art vacuum tube devices. Surface areas which range from 16 to 256 cm^2 have been tested, as described in the examples hereinafter. Although the scope of the invention is not believed to be limited by this range of surface area of values, it was generally observed that the larger the surface area of the anode/cathode tested, the more readily the pulse generator 50 elicited PAGD discharges providing other conditions such as plate material, vacuum, residual gas fill, voltage and current remained constant.

The preferred material for the cathode **54** and the anode **56** is aluminum. Two specific types of aluminum are preferred; namely, H34 rolled aluminurn available from the Alcan Company and Alzak™ aluminurn, available from the Alcoa Company. Other types of aluminum are assumed to constitute suitable material for cathode **54** and anode **56**. Aluminum is a preferred material because of its low work function for field emission as well as for its other qualities such as relative freedom from sputtering, except when subjected to vacuum arc discharges, and its electrical conductivity. In all instances, the aluminum used for cathode **54** and anode **56** were degreased and rinsed in accordance with published methods familiar to those skilled in the art.

Each of the cathode **54** and anode **56** is suspended within housing **52** by a support member **58** which passes through hermetic seal **60** an opposite sides of the housing **52**. The support members **58** are preferably rigid rods of substantially pure tungsten in a diameter of 1/16 th to 3/32 nd of an inch, or any suitable diameter. The material of choice is round finished PureTung ™ available from Union Carbide.

The pulse generator **50** also includes at least one axial probe **62** and the pulse generator **50** shown in FIG. 18 has a tetrode geometry with two spaced-apart axial probes **62**. Substantially pure tungsten rod is also the preferred material for constructing the axial probe(s). All tungsten rods used in assembling pulse generators in accordance with the invention were repeatedly cleaned with sodium nitrate and fused with a beaded sleeve of uranium glass #3320 available from the Corning Company or nonex™ glass #7720. These glasses are graded seals designed for high vacuum tungsten/pyrex junctions. Before the metal components of the pulse generator 50 are introduced into the glass housing 52, the housing is annealed at a temperature of 565° C. After the pulse generator was assembled, it was connected by a glass constriction tube to the glass manifold of a vacuum system (not illustrated).

An alternative geometry for a pulse generator in accordance with the invention includes a parallelepiped-shaped housing which is assembled using a suitable plastic polymer sheet. Polymer housings are preferably made from polycarbonate, specifically Lexan™ available from the General Electric Company. Especially preferred are the ultraviolet resistant Margard™ surface-treated Lexan™ MR5 or superior grades. The joints of the rectangular panels are preferably sealed with either a low vapour pressure resin Torr Seal™ available from the Varian Corporation which is applied along the mating edges to glue the panels or alternatively, an epoxy putty such as LePage's or MRCarbone's Handworkable Putty is first layered over the joints and then covered with translucent Scotch-Weld epoxy resin 2216B/A available from the 3M Company or another adhesive system suitable for withstanding the implosive forces of very high vacuum. For very large housings the walls are also preferably screwed together at spaced-apart intervals. Non-metallic internal braces can also be used to reinforce very large housings. The polyvarconate housings are cleaned as per manufacturer's instructions and all metal to polymer support interfaces, such as the hermetic seals where electrodes and probe(s) pass through a side wall of the parallelepiped-shaped housing are preferably epoxy resin joints made with Torr Seal ™. The vacuum constriction for connecting the housing to a vacuum pump is made of glass which is also joined to the polycarbonate surface using the Torr Seal™ epoxy resin. This alternative construction of pulse generator has a triode geometry which includes a single axial probe made of substantially pure tungsten rod. In all other respects it is the same as the pulse generator **50** described with reference to FIG. 18.

FIGS. 19a and 19b show transverse cross-sections of preferred constructions of pulse generators in accordance with the invention. FIG. 19a illustrates a cylindrical housing **52** with a flat plate anode **56** and cathode **54**. As shown in FIG. l9b, the anode **56** and the cathode **54** may be elongated, transversely curved sections which are substantially semi-cylindrical in shape. This anode/cathode geometry is actually preferred for cylindrical housings. The curved electrodes may be made from laser quality reflective aluminum foil about 200 microns in thickness. Such electrodes have a current tolerance of approximately 100 mA of direct current in the PAGD regime and are destroyed by disruptive slippage into arc discharge with as little as 900 watts of applied power. Curved electrodes of press-formed aluminum plate are therefore preferred over curved electrodes made from aluminum foil.

The following examples of tests conducted with discharge tubes **50** used as pulse generators illustrate the character and performance of such pulse generators.

EXAMPLE 6

Volt-ampere Characteristics of a Pulse Generator

The tests described in this example were conducted with a pulse generator **50** (device #1) constructed with H34 aluminum flat plates (128 cm^2 area) set 5 cm apart, and equidistantly from a continuous axial probe **62** in a vacuum which measured 10^{-6} Torr at time of seal off. FIG. 2, already discussed above, shows that under conditions of a positive, constant DC voltage applied to the anode **56** of this device, the volt-ampere curve for both breakdown potential (Vb, shown as open squares) and for the minimum discharge potentials (Vs. or VAD sustaining potential and Vx, or extinction PAGD potential, both shown as closed circles) disclose two regions or regimes in the operation of this device, a region of pulsed AGD which spanned from about 10 mA to about 150 mA RMS (with an applied maximum of 15 mA DC average), and a region of VAD at RMS current values greater than 250 mA. PAGD current data was derived from peak pulse RMS values and VAD RMS current data was obtained at steady-state. Within the range of the pulsed AGD, the Vb values were high and plateaued at about 850 volts; Vb values for the VAD regime were generally lower than those of the PAGD and could be raised by an increase in available current.

A PAGD regime could also be equally identified when the supplied DC voltage was negative and applied to the same cathode plate 54 (see FIG. 18), for both PAGD and VAD, Vb and Vx values (closed and open squares, respectively) at comparable transduced pulse RMS currents. Utilizing a 10-fold higher direct current power supply, also earth-grounded at the centertap but having a parallel supply capacitance of 55 mfd and a slow voltage recovery rate (ie. less than 200 V/sec), the same pulse generator 50 (device #1) yielded IOX higher peak PAGD RMS currents (2 A vs. 200 mA) than were obtained under the same conditions and with the same power supply by a positive applied voltage of equal magnitude. These findings suggest that, at high applied direct currents, there is a strong asymmetric response of the pulse generators **50** (larger PAGD RMS current values with cathodic tension than with comparable anodic tension) with respect to the sign of the plate polarization in reference to earth-ground.

It is also apparent that the field emission responsible for the PAGD regime does not obey the Fowler-Nordheim VAD region law (see FIG. 20): whereas the VAD graph has the expected negative slope, the slope of the PAGD graph is positive, contrary to predictions by the Fowler-Nordhetm VAD region law. This constitutes strong evidence for the existence of auto-electronic emission discharges that do not obey the behaviour predicted by the Fowler-Nordheim field-emission theory, the discharges occurring at much lower currents than predicted by that theory.

EXAMPLE 7

Pulse Count Rates in the PAGD Region

Two pulse count studies were done: a first at low applied direct currents (< 1.5 mA) and a second at mid to high applied direct currents (1.5 mA to 200 mA). Peak pulse RMS currents during the second study were as high as 2 A.

At low currents, using the pulse generator 50 (device # 1) assembled with H34 aluminum plates and ballasted with a 1 Mohm resistor and a lower pulse amplitude detection cut-off at less than 25V, the pulse per minute counts at the axial probe were observed to mcrease as the anode-supplied voltage (and the current, not illustrated), was incremented from 300 V to 500 V. At higher voltages the pulse count plateaued at a somewhat depressed level. Conversely, utilizing a pulse generator (device #2) assembled with Alzak plates in an identical vacuum at seal off (10^{-6} Torr), the pulse counts increased with applied voltage up to a maximum voltage applied, the maximum pulse count being about 9 times higher than observed with device #1. Reducing the ballast resistance mcreased the pulse rate of device #1 to a maximum of 1000 pps, or 60,000 PPM with a 0.125 ohm resistor, and increased the pulse rate of device #2 to 4000 pps or 240,000 PPM. Analysis of the pulse signals with an oscilloscope showed that, in both instances, the observed CPM values at the axial probe **62** effectively corresponded (about 1:1) to the PPM values at the cathode **54**, under these conditions for both devices #1 and #2.

At currents higher than 1.5 mA, when the PAGD regime is fully active, the inverse phenomenon was, observed: i.e. the pulse rates increased with a decrease in the value of the extinction voltage (Vx). They also increased proportionally to the transduced pulse RMS current. This was observed for both positive and negative polarizations of the 'vacuum', with pulse generator **50** (device #1) Under these conditions and with a 1 Mohm ballast resistor, rates of 113-124 pps were measured, the limiting factor being the recovery time of the voltage regulation of the power supply as the current drain increased. This phenomenon was exaggerated when no ballast was employed and the largest peak pulse currents were observed. With faster recovery power supplies capable of delivering the same or higher input currents (and having the same large value of capacitance in parallel with the plates) much higher pulse rates (greater than 1,000 pps) could be obtained, along with larger peak pulse RMS currents.

EXAMPLE 8

Detection of the PAGD Region in the Pulse Generator as a Function of Decreasing Pressure

Argon pumpdown tests were conducted to determine whether and when the PAGD region of the discharge was apparent utilizing comparably low voltages (up to 2.5 kv). These tests were performed with both the diffusion pump off and on. FIG. 21 shows a typical curve of the variation of the sustaining/extinction voltages at the plates with decreasing pressure at the rotary pump, from breakdown (at 860 VDC) to glow extinction, for all four pulse generators **50** examined (device #'s 3 to 6), which were assembled with H34 aluminum plates having different electrode areas: device #3, 16 cm^2 (small closed squares); device #4, 64 cm^2 (open circles); device #5, 128 cm^2 (open squares); device #6, 128 cm^2 (large closed squares). Each pulse generator **50** had the same gap distance of 5.5 cm and was assembled with the same volume of glass envelope. Devices #3 to 5 were evacuated simultaneously and an identical average direct current of 1 mA was applied to each separately, using comparable power supplies ballasted with a 1 Mohm resistor. Device #6 was evacuated in a separate test, under the same pumpdown conditions and at the same applied potential of 860 VDC at breakdown, but was subjected to a 100-fold higher, average direct current of 500 mA. It is readily apparent that the continuously varying, sustaining/extinction voltage curves shown in FIG. 21 are analogous to the Paschen gas breakdown voltage curve and that throughout most of the voltage range all three low current curves are parallel. Independent determinations of the low current breakdown voltage curves for an three pulse generators **50** (devices #3 to 5) showed the exact same relation for all three curves as observed for the sustaining/extinction voltage curves (results not shown). The differences between the electrical discharge regimes observed as a function of decreasing pressure are most apparent in the larger plate area pulse generator 50 (device #5). The three regions of the discharge, the transitional glow, the normal glow and the pulsed abnormal glow, are clearly distinguishable for that device (see FIG. 21). In the transitional region discharge (TRD), the cathode glow is of mirimal point-like size and rapid oscillations of the striations of the plasma positive column originate quasisinusoidal, dampened sinusoids, ramp-like or noise-like waveforms associated with sporadic, small amplitude (2 to 15 volts), pulsed auto-electronic emissions. In this region the voltage tends to fall, while oscillating erratically at first. As the pressure further decreases, there follows a stable normal glow discharge (NGD) region, where conduction of different current across the vacuum pre-empts the possibility of auto-electronic emission the lowest voltages are observed in this region. After the recession of the positive column and upon glow saturation of the plate areas, just as the cathode glow is beginning to recede (pre-Cooke's 'post-cathodic' phase), the intense, large amplitude (> 100 V), pulsed auto-electronic emission characteristic of the PAGD regime emerges. In this region, the voltage tends to climb until extinction occurs before the maximum voltage of 860 V is again attained. In the other two devices, the borders of the discharge regimes are blurred. In device #3, the low emissions intensity, small amplitude auto-electronic develop into a few high intensity, large amplitude emissions, as they decrease in frequency and with considerable overlap; the PAGD and NGD regimes are also mostly mixed, until lower pressures of the order of 0.01 Torr are attained, at which point the PAGD regime functions alone at low frequency. In device #4, the NGD regime can be better distinguished from the TRD, and the PAGD from the NGD, but high intensity, large amplitude auto-electronic emissions occur early on in the NGD region as the glow saturates the plates faster than for device #5. There is a dual effect on increasing the average applied direct current 100-fold (device #6, large closed squares, shown in FIG. 21): the entire ascending arm of the voltage curve is displaced upward in the pressure scale and the distribution of the voltage variation is compressed. The high applied direct current also abrogates the two discharge regions adjacent to the PAGD. From breakdown to extinction, the regime of the discharge is solely that of the PAGD, the positive column of the discharge weakening with the decreasing pressure. However, if the cathode is hot enough, a quasi-thermionic 'post-cathodic' glow may also briefly occur after the PAGD regime and before glow extinction.

FIG. 22 shows the pulse rates for the observed intense large amplitude, auto-electronic emissions characteristic of the PAGD regime, which correspond to the voltage curves for devices #3 to 5 obtained above as described for FIG. 21. In all three devices, the PAGD regime first appeared mixed together with the NGD regime in the form of pulses that perturbed the steadystate glow, the pulses increasing in frequency with the decreasing pressure until a maximum pulse rate was attained.

In FIG. 23, the effect on the PAGD regime of increasing the current 500-fold (from 1 to 500 mA), while keeping the potential constant using the same 128 cm^2 plate area pulse generator **50** (device #6) during two other separate evacuations with the rotary pump, is shown. The higher current displaces the PAGD region upward in the pressure scale, just as was observed in the ascending arm of the voltage curve (see FIG. 21). The displacement inducted by the applied high current occurs over a pressure range where, at low current (1 mA) and with the same applied potential at breakdown, some weak, low-amplitude, pulsed auto-electronic emissions are observed during the TRD. The effect of increasing the starting DC voltage at breakdown by 1.75-fold (from 860 to 1507 VDC) was observed using device #3 in two separate tests. The increased current displaced the PAGD upper pressure limit downward in the pressure scale, in opposition to the current effect and it also increased the frequency of the intense, large amplitude, auto-electronic emissions by a factor of about 8.8.

Using the same applied low direct current and potential magnitude at breakdown (860 VDC) described for the tests repre-

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sented in FIGS. 21 and 22, pumpdown of the three different plate area pulse generators **50** (each having interelectrode distances of 5.5 cm) was performed with the oil diffusion pump on. While the effect of increasing the plate area under these conditions remained the same, i.e. lowering the pressure for the same sustaining/extinction potential and displacing the PAGD region to regions of higher vacuum, there was a noticeable difference compared with the same test done with the rotary pumpdown: i.e. the extinction pressure was greatly extended downward in the pressure scale for all devices, and, consequently, the PAGD region was greatly expanded into the medium to high vacuum ranges. A 128 cm^2 plate area pulse generator **50** with 5.5 cm gap, (devices #11 and 12) typically reached PAGD extinction at $5*10^{-5}$ Torr, though its peak pulse rate remained basically unchanged. This overall displacement of the PAGD phenomenon to higher vacuum regions under conditions of oil diffusion evacuation may well be due to the migration of very low vapour pressure oil molecules to the tube ends (despite the baffle and the cooling trap) and their interaction with residual gas molecules in the electrical field of the devices. With the diffusion pump on and voltages progressively increasing up to 2.5 kV with decreasing pressure, the PAGD regimes in these pulse generators **50** operated from 10^{-3} to 10^{-5} Torr. Typically a 128 cm^2 H34 aluminum plate pulse generator **50** (5.5 cm gap) will operate in the PAGD regime at $2*10^{-5}$ Torr, with an applied voltage of 2.2 kV and at a pulse rate of 30 pps. With higher vacua (<10-5 Torr) and voltages, the 'post-cathodic' PAGD gives way to the production of cathode rays and very weak x-rays. From several such diffusion pumpdown tests it was concluded that the PAGD was facilitated by the use of Alzak electrode material and, as it will be shown in Example 9, by larger plate areas.

EXAMPLE 9

The Effect of the Plate Area on the PAGD Characteristics during Pumpdown

The effect of increasing the plate area of the cathode **54** and anode **56** of a pulse generator **50** was tested by two methods: 1) using a pumpdown method of varying the vacuum with a rotary pump (as explained below) and 2) using sealed housings **52**, **64** enclosing a vacuum of $2*10^{-6}$ Torr obtained with the diffusion pump (see Example 10).

The results from the first test is shown in FIGS. 21 and 22, for the pulse generators **50** stimulated with low (1 mA) direct currents, at the same starting potential of 860 VDC at breakdown. A comparison indicates that the effect of increasing the plate area in pulse generators **50** having the same gap distance, and thus the same pd value (pressure, in Torr, multiplied by interelectrode gap distance, in cm), and the same volume, is to depress the voltage, particularly in the NGD and PAGD regions and to displace the auto-electronic pulsed emission characteristic of the PAGD regime to a higher vacuum range. The peak frequency of PAGD for each given area is also attained, in each case, at a vacuum that increases proportionately to the order of increasing area (16→64→128 cm^2) as does the magnitude of the peak frequency of PAGD for a given gap distance. The distribution of PAGD frequencies also narrows its characteristic mode with the larger area plates, by displacing an upper pressure limit to lower pressure regions, the most significant shift in this respect being from the 64 to the 128 cm^2 devices (FIG. 12, open circles vs. open squares). This distribution compression shift corresponds to a better definition between the NGD and the PAGD regimes afforded by the pulse generator **50** with the largest plate area employed (128 cm2), as discussed above in Example 8. Moreover, in accordance with] Paschen's law, the observed area-dependent voltage reduction effect cannot be explained, inasmuch as the voltage is predicted to remain the same as long as the product pd is constant even if the plate area increases. Since the interelectrode gap distance was constant for all devices and as the pumpdown was also performed simultaneously, it is apparent that there is an electrode plate area effect which is not accounted for by Paschen's law. The observed plate area effect appeared to have an effect opposite to current and in the same direct i tion of increasing potential, as it displaced the PAGD region downward in the pressure scale and increased the PAGD frequency. In addition, an increase in area also reduces the magnitude of the potential. From the . results obtained, it is apparent that an increase of 1.75 fold for a given breakdown potential of a 16 cm^2 pulse generator yields the same pulse rate (about 60 pps) as does an 8 fold increase in plate area for the same volume housing (**52, 64**), but requires a lower pressure.

A comparison of breakdown order and pressure, as well as of peak pps values and peak pps conditions carried out as a function of plate area for the pulse generators **50** (devices #'3 to 5) represented in FIGS. 21 and 22, showed that the pulse generator **50** with the largest plate area, which was the first to undergo breakdown (during six separate tests) at the highest pressure of 3 Torr, yields an 8 fold higher PAGD rate than the pulse generator **50** with the smallest plate area of 16 cm^2, at the lowest pressure (the pressure is 24 times lower than that of the 16 cm^2 device). This peak pps rate occurs, however, at a voltage which is about 9.5% greater for the pulse generator **50** with the largest plate area. These results suggest that a larger plate area promotes breakdown at higher pressures (i.e. the breakdown pressure decreases inversely to the order of increasing plate area) and supports lower sustaining/extinction voltages.

In conclusion, the effect of increasing the plate area of pulse generators stimulated with the same starting voltage and the same current is to: 1) shift the breakdown pressure upwards, 2) depress the working voltage, 3) increase the pulse rate both in the TRD and the PAGD regions, 4) shift the PAGD region downwards in the pressure scale and segregate the discharge regimes more clearly as a function of decreasing pressure. These observations also explain why the pulse generators with smaller plate area shift the PAGD up in the pressure scale, as an increase in current does. Effectively, a smaller plate area not only concentrates the lines of electrostatic force in a vacuum, but it also increases the current density per unit area, with the consequent glow saturation of the plates, necessary for the abnormal glow discharge region to be attached, occurring earlier on during pumpdown, than for pulse generators with larger plate areas.

EXAMPLE 10

The Effect of Plate Area on the PAGD Characteristics of Pulse Generators Enclosing a High Vacuum

The second method used to test the effect of increasing the electrode plate area in the design of a pulse generator **50** made use of glass housings **52** enclosing a final vacuum of $2*10^{-6}$Torr obtained with a diffusion pump on. These tests were performed with high direct currents (200 mA to 1 A). All pulse generators tested (devices #'s 7 to 13) had an interelectrode gap distance of 5 cm, enclosed the same volume and the same vacuum, and were assembled at H34 aluminum plates having plate areas which varied by an area factor of k_A=2, namely: 64, 128 and 256 cm^2. Originally the test was performed with a series with a $k_A=2^2$ factor, the plate areas being described by 2^4, 2^6, 2^8 or 16, 64 and 256 cm^2. However, at a seal off vacuum of $2*10^{-6}$, the first two pulse generators **50** of this series (16 and 64 cm^2, devices #'s 7 to 10) remained unresponsive (no signs of discharge). Even when 3.3 kV was applied, one of the 64 cm^2 pulse generators showed only a faint glow (also see discussion of results for groups #1 and #4 of Table 5 below). The results for the k_A=2 series indicate that when the current, the interelectrode distance and the pressure are all kept constant, the breakdown potential (Vb) for the PAGD decreases with an increase in plate area. For the largest plate area tested (256 cm^2), the PAGD breakdown (287 V) and extinction (Vx=284 V) voltages practically coincide, suggesting that larger areas might depress both Vb and Vx still further. These results were recorded under identical conditions of applied direct current (200 mA), of peak pulse RMS current and of pulse frequency (20 pps) using an earth-grounded centertap power supply with both positive and negative voltages applied simultaneously to the respective plates. Under the same conditions of applied total power same starting voltage, but higher applied direct current because of their lower sustaining/extinction voltage), three pulse generators **50** built with Alzak plates having areas of 64, 78 and 128 cm^2 respectively were tested with the same power supply.

These pulse generators conduct 5-fold higher DC currents, transduce 3-fold higher peak pulse RMS currents and yield a 20 to 30-fold increase in pps (from 20 to 600 pps) at similar field strengths, when compared with the results obtained using hardened aluminum plates.

A comparison of pulse counts at the axial probe **62** (see FIGS. 18 and 19) in pulse generators **50** and the pulse counts at the cathode **54** showed that the axial probe **62** accurately reflects interelectrode events. This correspondence was confirmed using oscillographic analysis of the probe waveform, which showed it to be functionally equivalent to that measured at the cathode **54**.

Typically, for a closed high vacuum pulse generator **50** with a plate area of 128 cm^2 and an interelectrode gap of 5 cm, a breakdown voltage of 668 volts, an average applied current of 500 ma, and at 200 pps, the pulse amplitude is more than 300 volts. Under rotary pumpdown conditions and for an identical pulse generator, the pulse amplitude (encompassing both positive and negative components, the latter being the prominent value) increases with decreasing pressure, from 60 volts at about 0.5 Torr (with 5 mA DC) to >300 volts at 0.008 Torr. In the closed high vacuum pulse generator with H34 plates having an area of 128 cm^2(device #1), higher resolution oscillographs taken at the axial probe **62**, show that the negative component precedes the positive reversal and has a typically higher amplitude (140 V vs. 80 to 120 V, respectively, for example). Clearly, upon an abnormal glow discharge pulse, the recovery of the field strength within these pulse generators overshoots a 'closed switch state' (where the current I~O) and results in a net flow of positive charge past the probe, towards the cathode (which is the floating ground reference level for these measurements).

EXAMPLE 11

Effect of Capacitance on PAGD Rate

Using the same breakdown voltage of about 668 VDC, the effect of varying the capacitance of the power supply, set in parallel with the pulse generator (device #1), on the frequency of PAGD production was determined while maintaining all other variables constant (interelectrode gap, plate area, applied voltage and current levels). Linear regression shows that, under these conditions, the PAGD frequency is increased by lower capacitances. The log slope indicates that the pps rate is doubled as the capacitance decreases by i rds. Measurements were also taken of the 'non-dynamic' capacitances of pulse generators with H34 aluminum plates having different plate areas. These were insignificant when compared with the parallel capacitances used in the power supply, used in the tests, and were observed to vary in accordance with the dielectric law, i.e. doubling the plate area doubled the capacitance. This can be seen in the Table below:

Plate Area	Capcitance
64 cm^2	$1*10^{-12}$ F
128 cm^2	$2.05*10^{-12}$ F
256 cm^2	$4.1*10^{-12}$ F

Optimum Arrangement and Geometry

Prolonged operation of the pulse generators **50** has provided the geometries for eliciting PAGD production including:

I) It is advantageous if the discharge does not wander to the back of the anode **56**/cathode **54** and this is facilitated by using semi-cylindrical anode 56/cathode 54 in cylindrical housings 52 and flat anode 54/cathode 56 (rectangular, square or circular) in parallelepiped-shaped housings. However interelectrode gap tests are best done with flat plates which assure an homogeneous potential. Moreover, the semi-cylindrical electrodes are best made of hardened aluminum, at least 0.5 to 1 mm thick, and this requires forming them to the right curvature, given that foil alternatives are not resistant to the deleterious effect of high-current PAGD transduction at very high frequencies and do not withstand disruptive VAD discharges. Nonetheless, a semi-cylindrical electrode configuration in a housng **52** makes the sheaths (where ionic recombination occurs during glow discharge) near the electrodes and the housing wall coincide, and this can be highly advantageous for sustaining PAGD production. The same applies to flat plates in flat surface parallelepipPd housings.

2) The most effective axial probe **62** is either a single half-length rigid rod or a pair of axial probes **62** separated at the center of the pulse generator **50** by a gap of more than 1 cm, 4-6 cm being optimum. Whereas an axial wire will perform satisfactorily as a probe **62**, the rigid rod has the advantage of not yielding to a direct mechanical transduction of the electrodynamic force effected upon it by the discharge or to force created by the acquisition of a constant space charge. A split axial probe **62** facilitates the exciter function and assures PAGD operation by preventing a formation of a stable axial space-charge at high-current operation.

3) A cooling coil (made of rubber, polymer, glass or copper tubing) surrounding housing **52** is useful to counterbalance the heating of the anode **56**/cathode **54** which promotes the production of semithermionic VAD channels and even thermionic normal glow discharges, specifically at applied currents of more than 200 mA during PAGD operation. A coolant pipe system that weaves through the plates can also be used for this purpose, in which case flat plates are preferred.

4) Larger anode **56**/cathode **54** surfaces are required as the interelectrode gap is increased. And inversely, larger anode **54**/cathode **56** surfaces operate best (i.e. require the lowest applied voltages) if larger interelectrode gaps are used; however, the breakdown voltage also increases with larger interelectrode gaps.

5) One of the limitations of these pulse generators stems from their continuous operation at high applied currents and from eventual slippage into the VAD regime, both of which promote a deposit of sputtered metal atoms on the inner walls of the housing **52** thereby making them conductive. In order to minimize this problem, electromagnets may be wound longitudinally over the housing **52** (one at each end), to limit the dispersion of the discharge vortices.

Factors Affecting PAGD Production

It is apparent that several factors affect PAGD production namely: cold cathode work function, voltage, current, parallel capacitance, gas fill, pressure, geometry plate area and interelectrode gap distance. Except for capacitance at the high end of the scale, each of these factors affect the high and low limits of the PAGD, for any given set of conditions. Heretofore, factors such as plate area in vacuum tubes have not been previously identified as factors which affect the breakdown field values and the sustaining/extinction potentials of a glow or an arc discharge. This suggests that the observed auto-electronic field emission in the PAGD regime is a function of physical factors which to date have been unrecognized. It further suggests that field emission is not a property exclusive to the VAD, i.e. that it is also a property of the pulsed operation of an abnormal glow discharge in low to very high vacua.

The present pulse generators **50** provide an optimal design capable of transducing high peak pulse currents at very low field

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strength, over a wide range of frequencies with minimal slippage of the PAGD operation into either the NGD or the VAD regimes.

In conclusion, we have disclosed a series of low to very high vacuum pulse generators which support the production of PAGDs. In testing these devices we have shown that:

the low field strengths and typical low emission current densities observed in the PAGD regime are not predicted by any existing field emission or space-charge theories;

the PAGD regime responds asymmetrically to the polarity of the applied voltage at high applied currents;

at low applied currents, the PAGD pulse rate increases with the applied voltage and the current up to an observed plateau;

at mid to high applied currents, the PAGD pulse rate increases with an increase in current and with a lowering of the extinction potential;

the PAGD pulse rate also varies with the composition of the cathode material (the pulse rate is promoted by materials having a low work function) and increases with a decrease in pressure, during pumpdown, to a maximal peak rate, thereafter either diminishing to the point at which the discharge extinguishes or gives way to x-ray production (depending on the magnitude of the appliedpotential);

larger area plates lower the field strength values needed to elic it comparable PAGD production, displace the PAGD region downward in the pres-: sure scale and increase the peak PAGD rate;

higher power supply capacitances slow down the PAGD rate.

We claim:

1.A direct current power transducer comprising a cold cathode vacuum discharge tube having an anode and a cathode and capable of autoelectronic emissions under abnormal glow discharge conditions, which emissions have an extinction potential substantially higher than the sustaining potential of a vacuum arc discharge in the same tube, and an external circuit including a direct current source connected between the anode and the cathode, the external circuit being capable of developing a potential sufficient to initiate said autoelectronic emissions, and an impedance sufficient that, as the autoelectronic emissions are established, potential between the anode and the cathode collapses below said extinction potential before a vacuum arc is established, thus setting up an endogenous cyclical pulsed abnormal glow discharge, wherein the external circuit includes a reactive arm in parallel with the discharge tube and presenting a capacitance across the tube, said reactive arm further including an electromagnetic device providing an energy output and dependent on the application of cyclical power pulses for its operation.

2.A transducer according to claim 1, wherein the electromagenetic device comprises a rotary electric motor having a stator converting cyclical power pulses into a rotating magnetic field and a rotor rotating in that field.

3.A transducer according to claim 2, wherein the motor is a synchronous motor.

4.A transducer according to claim 2, wherein the motor is an asynchronous induction motor.

5.A transducer according to claim 2, including electric motors connected in tandem.

6. A transducer according to claim 2, including plural discharge tubes connected in tandem.

7.A transducer according to claim 1, including at least one auxiliary electrode influencing emissions within the tube.

8.A transducer according to claim 7, including a connection between said auxiliary electrode and said external circuit to affect an operational parameter of the transducer.

9.A transducer according to claim 1, including at least one auxiliary electrode influencing emissions within the tube, and a connection between that auxiliary electrode and a point within the reactive arm selected to increase a cycling rate of the pulsed abnormal glow discharge.

IO.A transducer according to claim 1, wherein the tube contains multiple cathodes and a common anode, and the external circuit is configured to develop a potential sufficient to initiate autoelectronic emissions between the anode and each cathode in turn to produce multiple endogenous cyclical pulsed abnormal discharges, the effects of which are combined in the external circuit.

11.A transducer according to claim 10, wherein the tube contains two cathodes and the external circuit provides both capacitance between each cathode and the anode and inductances coupled in antiphase between the cathodes.

12.A transducer according to claim 1, wherein the electromagnetic device is a synchro-transmission system providing a remote output.

13.A transducer according to claim 1, wherein the electromagnetic device is a transformer.

* * * * *

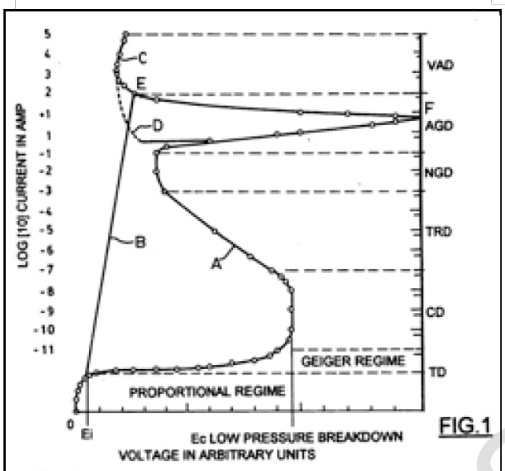

FIG.1

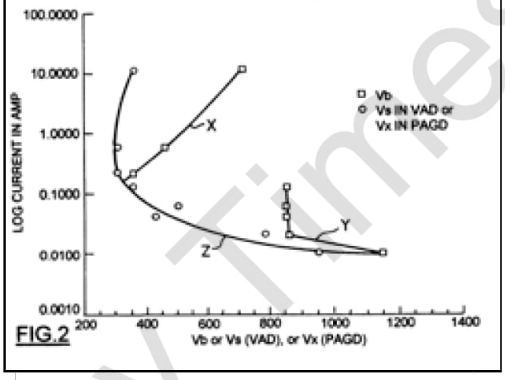

FIG.2

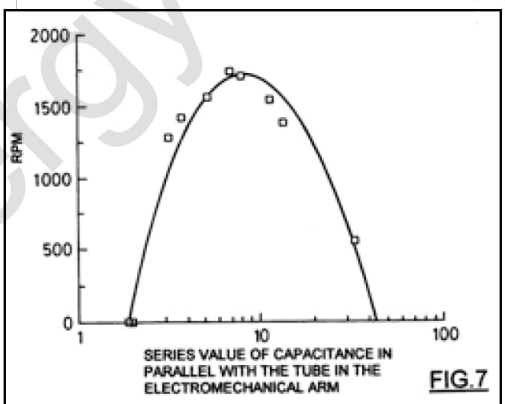

FIG.7

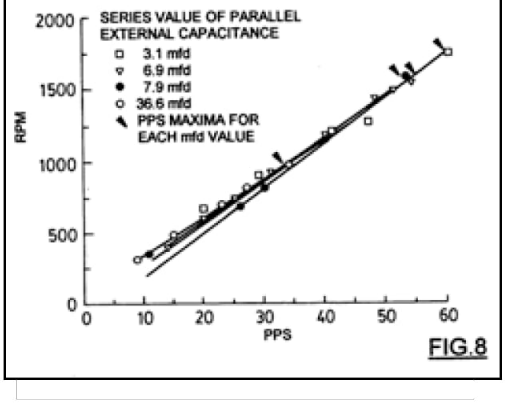

FIG.8

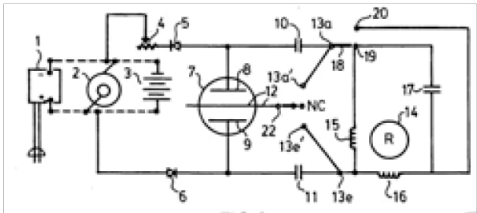
FIG.3

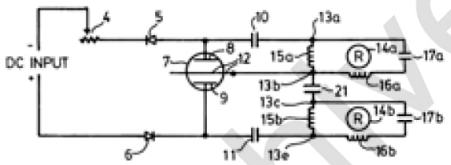

FIG.4

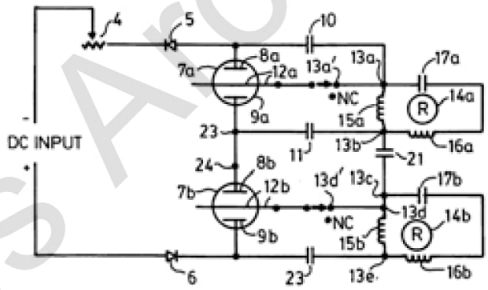

FIG.5

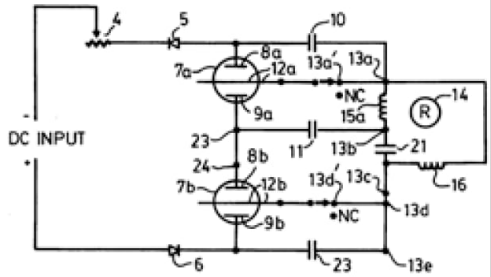

FIG.6

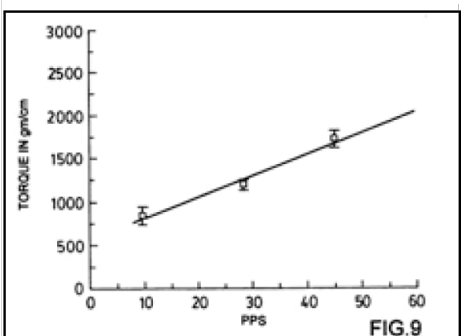

FIG.9

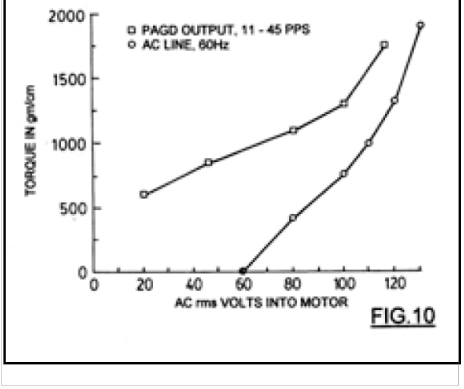

FIG.10

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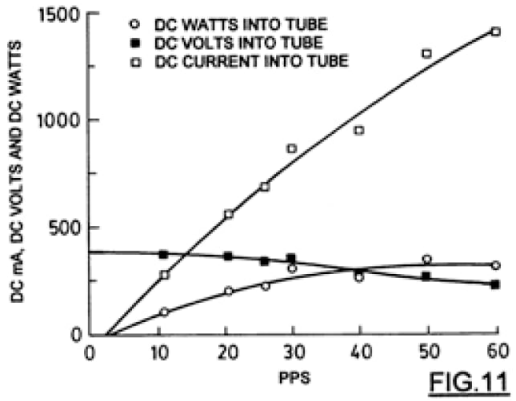

FIG.11

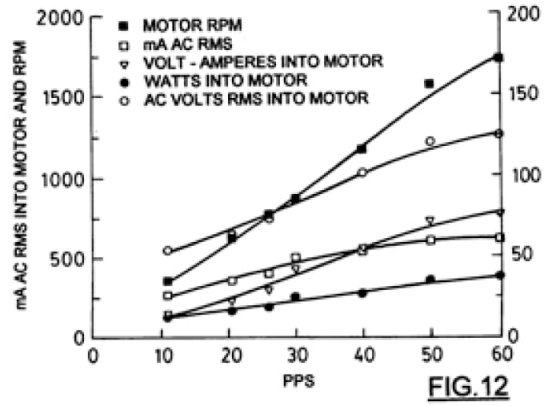

FIG.12

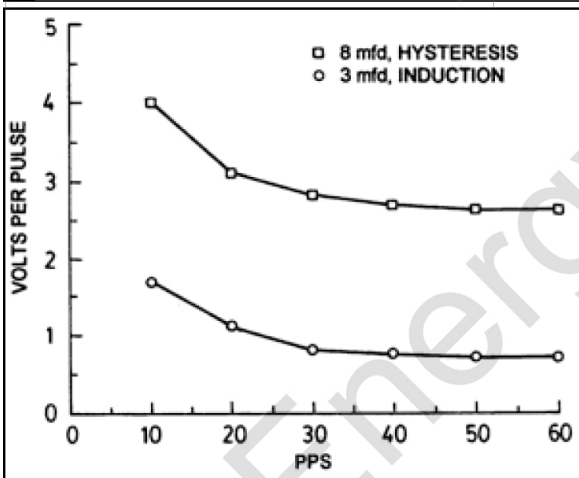

FIG.13

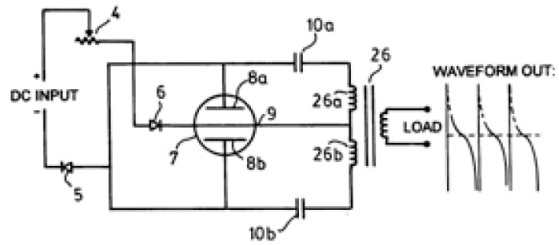

FIG.14

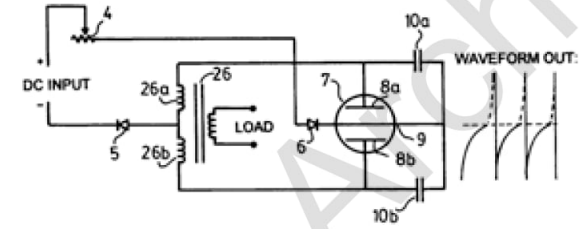

FIG.15

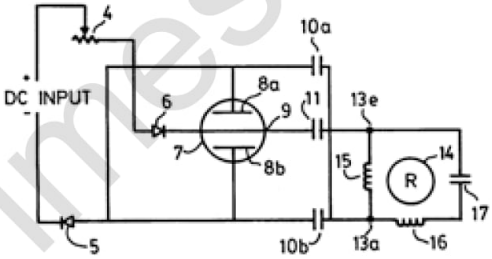

FIG.16

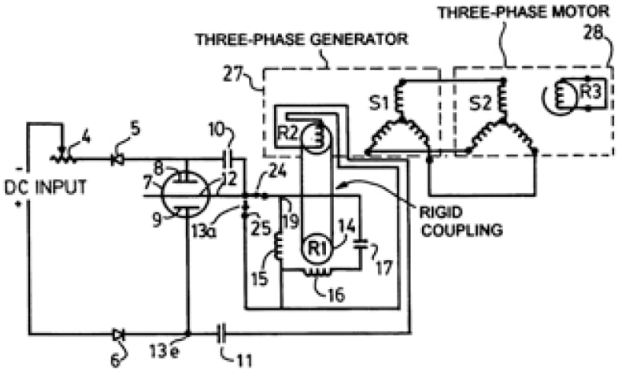

FIG.17

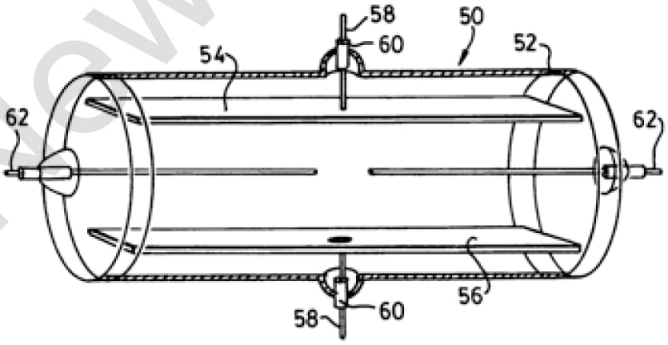

FIG.18

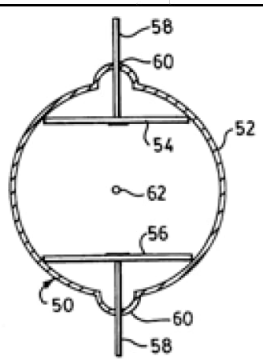

FIG.19a

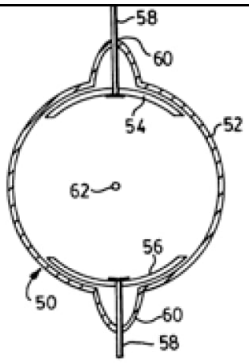

FIG.19b

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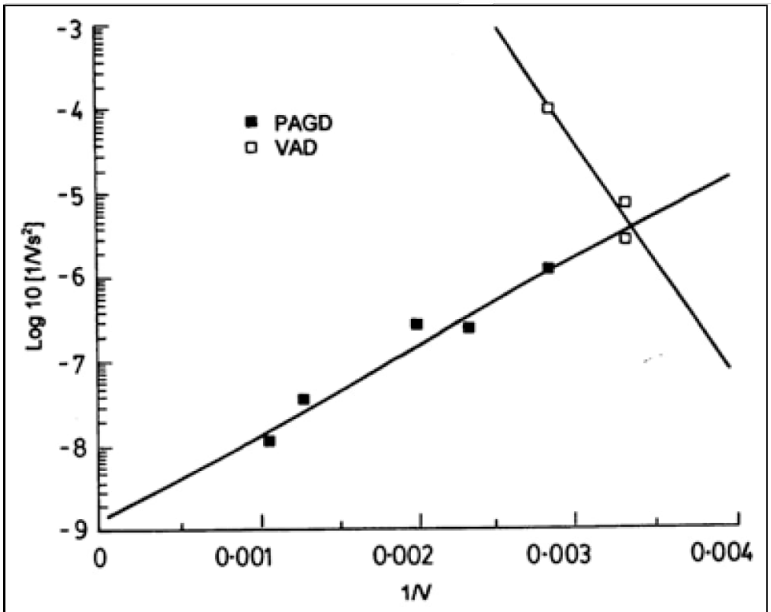

FIG.20

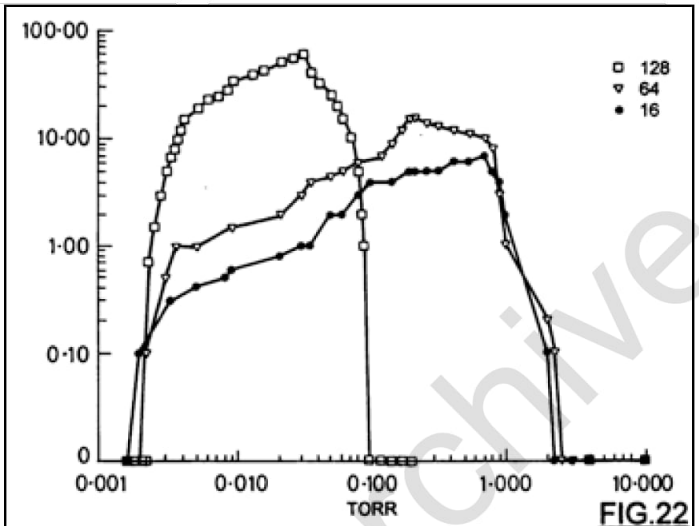

FIG.22

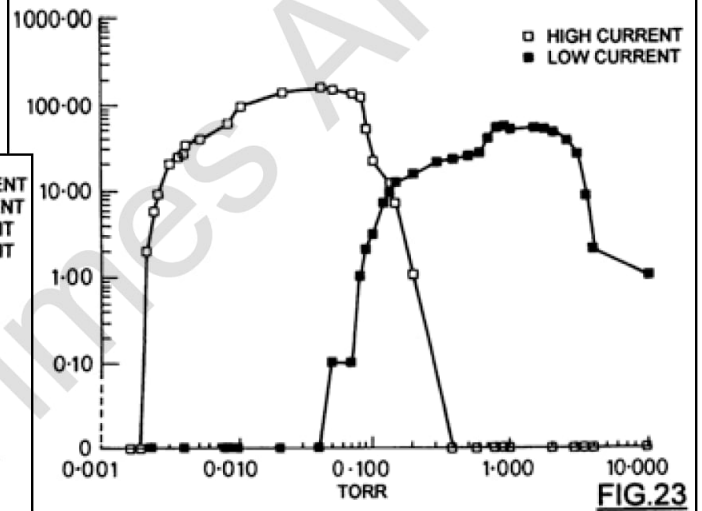

FIG.23

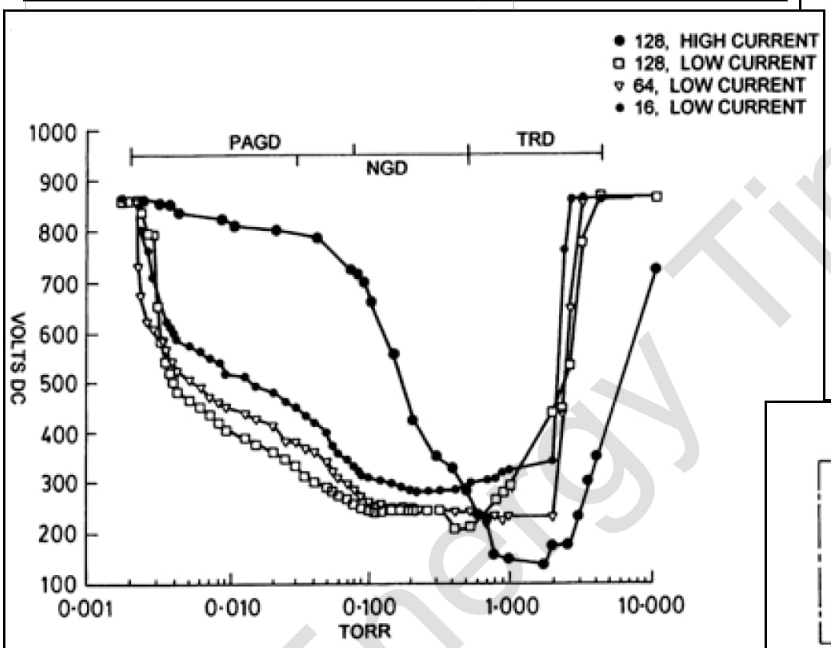

FIG.21

Alexandra Correa hard at work glassblowing.
©Correa & Correa

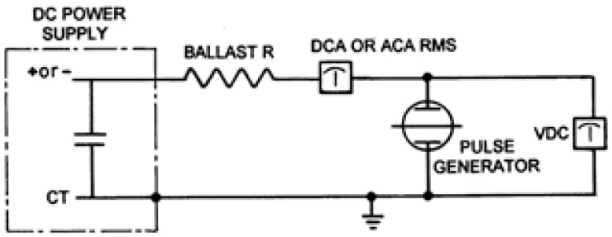

FIG.24a

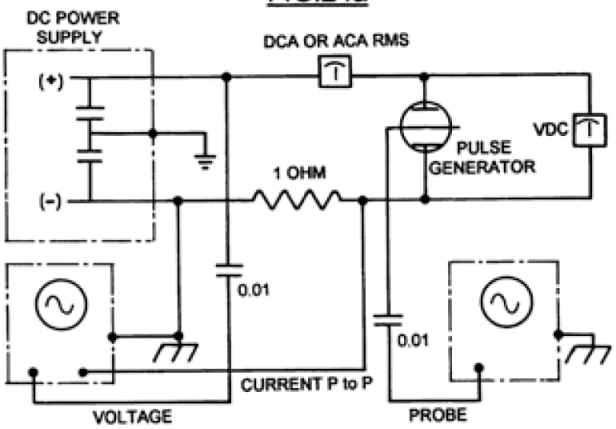

FIG.24b

New Energy Times Archive

The second *Correa et al.* patent — U.S. #5,449,989 provides copious experimental evidence of massive over-unity performance—100's to 1,000's of Percent more electricity out than input. Only a small quantity of the published results are presented here.....

Patent Number: 5,449,989
Date of Patent: Sep. 12,1995

ENERGY CONVERSION SYSTEM

Inventors: Paulo N. Correa;
Alexandra N. Correa, both of 42 Rockview Gardens, Concord, Ontario, Canada,L4K 216

Appl. No.: 54,111
Filed: Apr. I5, 1993

Related U.S. Application Data
Continuation-in-part of Ser. No. 922,863, Jul. 31, 1992, abandoned, and Ser. No. 961,531, OCt. 15, 1992, Pat. No. 5,416,391.

Primary Examiner—Bentsu Ro

ABSTRACT

An energy conversion device includes a discharge tube which is operated in a pulsed abnormal glow discharge regime in a double ported circuit. A direct current source connected to an input port provides electrical energy to initiate emission pulses, and a current sink in the form of an electrical energy storage or utilization device connected to the output port captures at least a substantial proportion of energy released by collapse of the emission pulses.

23 Claims, 13 Drawing Sheets

Editor's Note: We reproduce here a key portion of the patent that indicates results of the electrical input and output measurements made on the input battery ("drive pack"—DP) and output battery ("charge pack"—CP).

.....

Under these experimental conditions, exact power measurements could be taken from an analysis of the actual battery discharge curves before and after the PAGD run. Based on a comparison of the curve trends of the pre-run resistive discharge of the drive pack with those of the post-run resistive discharge, the effective power drawn (ΔE_c) from the withdrawable power capacity of the drive pack incurred during a PAGD run, was ascertained. This represents the power consumption during the run, and the experimental value thus recorded constitutes the actual power figure that must be matched for breakeven (BE) to occur. Hence, the breakeven value equals, by definition, the electrical energy input to the system. Similarly, a comparison of the charge pack pre-run and post-run resistive discharge curve trends identified the effective power (ΔE_p) added to the withdrawable capacity of the charge pack. This quantity represents the electrical energy recovered during the run. The relation for the two quantities is expressed by the breakeven efficiency (BE= %) equation:

$$\% = \Delta E_p / \Delta E_c \cdot 100$$

If the breakeven efficiency is less than %=100, then the apparatus registers a net loss in electrical energy in the CP with respect to the DP. Conversely, if % > 100, then there is a net gain in electrical energy in the CP, as compared to that lost in the DP. For purposes of this analysis, a limit to the minimum withdrawable capacity was placed, from experiment and in agreement with the load current curves of the manufacturer, at 115 W for the driver pack (average current of 0.250 A, minimum current of 0.230 A), and at 90 W for the charge pack (average current of 0.375 A, minimum current of 0.334 A), as a function of both their total cell size (respectively, 46:29) and the difference in the resistive loads employed for the discharge measurements. All cathodes had been broken in, as described before.

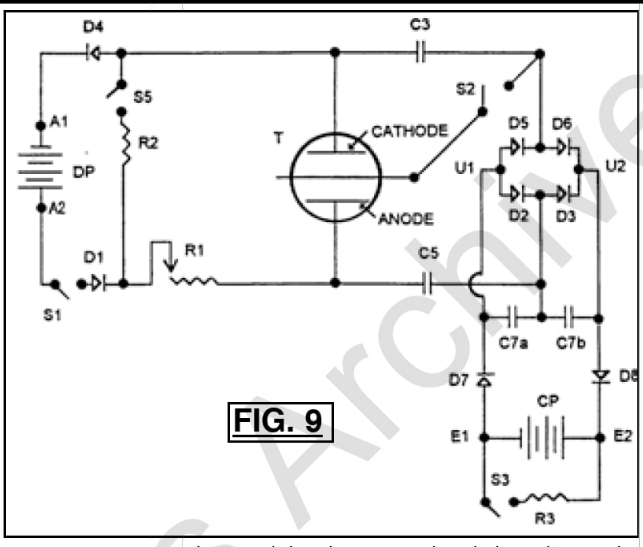

FIG. 9

The results obtained with this fourth method, for six selected experiments with three diverse types of devices (using different electrode plate areas, gap lengths, and electrode work-functions), configured both in the triode or the (single) diode (e.g. FIG. 10B) arrangements, at the indicated pressures, are presented in **Table 8.** In all cases, a net excess of combined battery pack charge, expressed as electrical watt hours, is registered (columns 8 and 10, **Table 8**) and the breakeven efficiencies are all > 100% (column 10). Experimental groups #I and #2 again demonstrate that, for the same cathode, the interrupted PAGD sequence method of group #2 (1 minute of PAGD function, followed by a 15 minute relaxation, and so on) yields a higher breakeven efficiency because of the lower losses registered with this minimal plate heating method (column 10, Table 8). Group #3, Table 8, shows that the PAGD power production efficiency is also higher for a lower work-function cathode material (H220 vs H34), being subjected to PAGD auto-electronic conditions at a 4-fold lower pressure than the control groups #I and #2; however, the lower pressure depresses the frequency and, together with the interrupted PAGD sequencing method, it also lowers the loss, causing an actually much larger breakeven value than registered for the previous two groups. Groups #4 and 5 exemplify the dual effect of lowering both the plate area and the gap distance: the former affects the PAGD event frequency, whereas the latter affects the PAGD amplitude, and thus the capture efficiency of the charge pack. Despite a cathodic workfunction practically and operationally identical to that of groups #I and 2, these smaller plate area and shorter gap devices utilized in groups #4 and 5, yield 3- to fold lower net power outputs, as well as lower breakeven efficiencies, than the former groups, at the same pressure. Finally, group #6 exemplifies the results obtained for the plate diode configuration, where the frequency is lower (no triggering role for the axial member), and a higher loss leads to the lower breakeven efficiency, comparable to that of the lower area and shorter gap groups #4 and 5.

In order to verify the discharge curve lengths employed in these analyses and experimentally establish the actual charge capacity of the battery packs, calibration resistive discharges, between the maximum charge state and the minimum limits chosen, were performed for each pack with their respective discharge resistances R2 and R3 (see FIG. 9). These discharge calibration curves were plotted for half maximal charge values shown in **FIGS. 15A and 15B**, and from the curve produced, we have determined the total half-charge capacities of each battery pack to be 1.033 kWh (100%=2.066 kWh) for the drive pack and 660 Wh (100%=1.320 kWh) for the charge pack. Based upon the corresponding maximal (100%) capacity values, we determined the actual percentages of the relative charge capacities shown in column 5, Table 8, which correspond to the experimental values obtained. We also noted that the curves plotted showed two quite distinct time linear slopes, the slope of the delivery of power per time unit steepening very markedly at the approach to the limits of the permissible withdrawable capacity, occurring at 115 W into R2, and 90 W into R3. The pre-PAGD run and post-PAGD run, drive and charge pack discharge curves corresponding to groups #3 and #6, respectively for triode and plate diode con figurations, in **Table 8**, are shown in **FIG. 16** (drive pack) and **17** (charge pack), for group #3, and in **FIG. 18** (drive pack) and **19** (charge pack), for group #6. In all cases, the open symbols represent the pre-PAGD run discharge curves, whereas the closed symbols represent the post-PAGD run discharge curves.

As a further check on these values, a videographic millisecond analysis of the singular power simultaneities occurring at both ends of the system (drive and charge packs) was performed for various 10 second samples of diverse PAGD runs. A typical example is shown in **FIG. 20**, which is a sample of the PAGD run designated as #6 in **Table 8**. Whereas the drive pack DC wattage spent as input to PAGD production varied from 36.6 to 57.82 watts, by a factor of 1.6x, the DC wattage entering the charge pack as captured PAGD output varied more pronouncedly by a factor of 2.7x, from 146.4 to 399.6 watts (all meters were in the same selected ranges of voltage and current) with the semi-periodic, intermittent character of each singular emission, though within specific, ascertainable ranges for both amplitude and current outputs. Assimilation of the singular behaviour of the PAGD in this sample, by a statistical treatment of its variation (n = 64), indicates that the operational breakeven efficiency observed during this sampled period lies at 485.2% + 18% with projected 48.3Wh drive pack loss and 221.7Wh charge pack gain. This matches rather closely the observed 483% breakeven efficiency, and the 37.7Wh loss as well as the 182.2 Wh gain for the overall PAGD run reported in group #6, **Table 8**, and indicates how close are the values obtained by the operational and extensive non-negligible resistive discharge power measurement methods employed.

Finally, an example of the correlation between the drive pack PAGD load voltage and the charge pack PAGD charging voltage, as a function of the duration of the intervening PAGD run between resistive discharge measurements, is shown in **FIG. 21**, for the PAGD run corresponding to group #4, **Table 8**.

Using the same pulse generator with H200 AL 128 cm^2 plates, in a double diode configuration, and the same circuit values (but with CP=23 cells), three experiments were conducted at different PAGD frequencies, as a function of varying air pressure. Analysis of driver pack losses and charge pack gains by the extensive load discharge measurement method, as described

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before, led to the determination of the gross and net gains (respectively, without and with losses included) per pulse, in milliwatt-hour, for each frequency, as well as of the gross and net power gains per second of PAGD operation. The results are shown in **Table 9**. ***[Editor's note: not printed here.]*** Even though the gross and net gains of power per pulse were observed to increase with decreasing frequency, the gross power gain per unit time increased with increasing frequency. However, this last trend does not necessarily translate into a higher net gain per unit time, because the losses in the driver pack (not shown) also increase significantly with PAGD frequency. These losses are in all probability related to more energy retention by the plasma at higher frequencies when plasma extinction becomes incomplete. We expect net gains to reach optimal thresholds for any given type of circuit configuration set of values and pulse generator dimensions.

• • • • • •

Table 8 is on Next Page

Photo below: Six video-frame shots of PAGD discharge sequence (from a color laser print).

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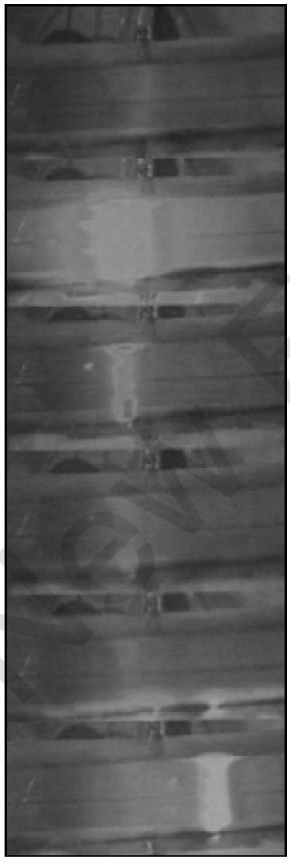

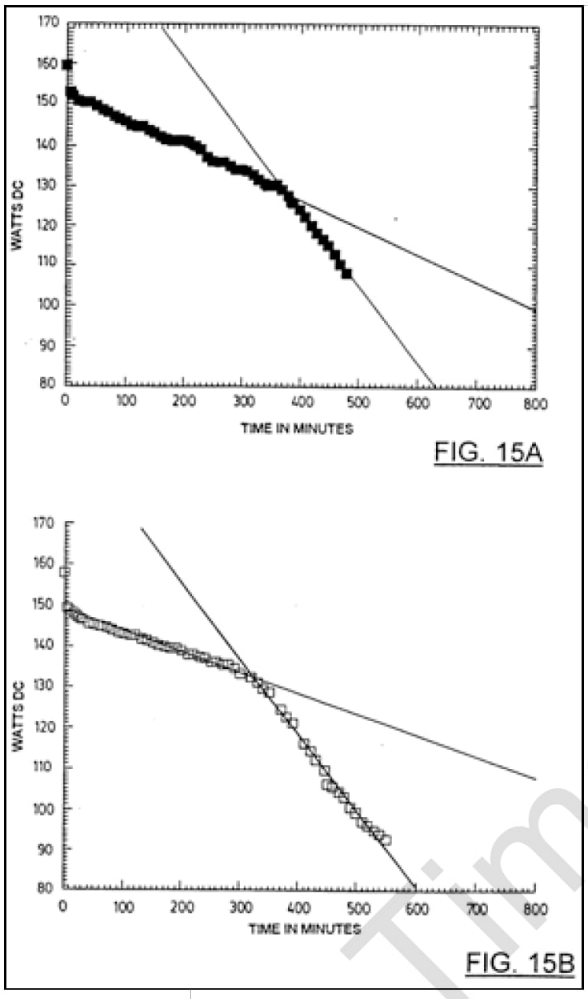

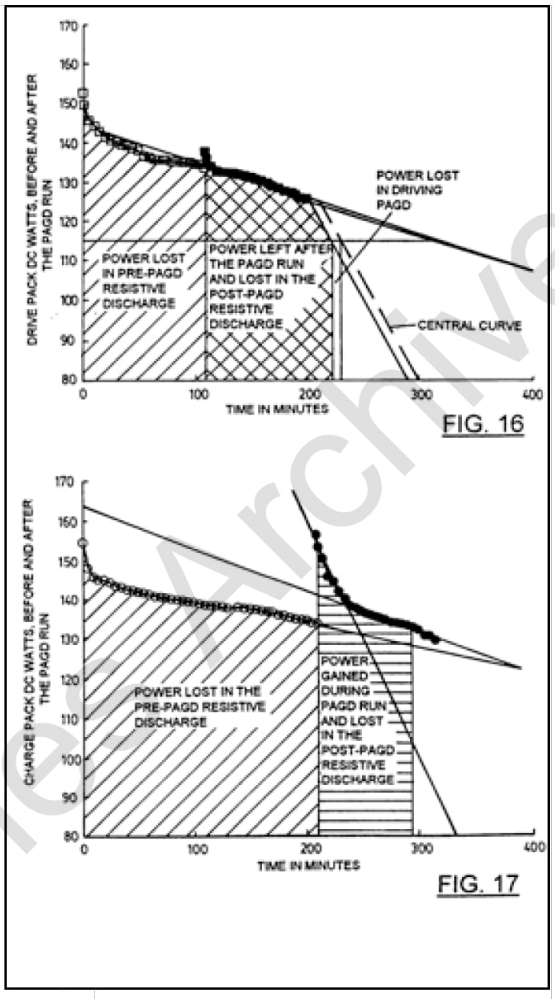

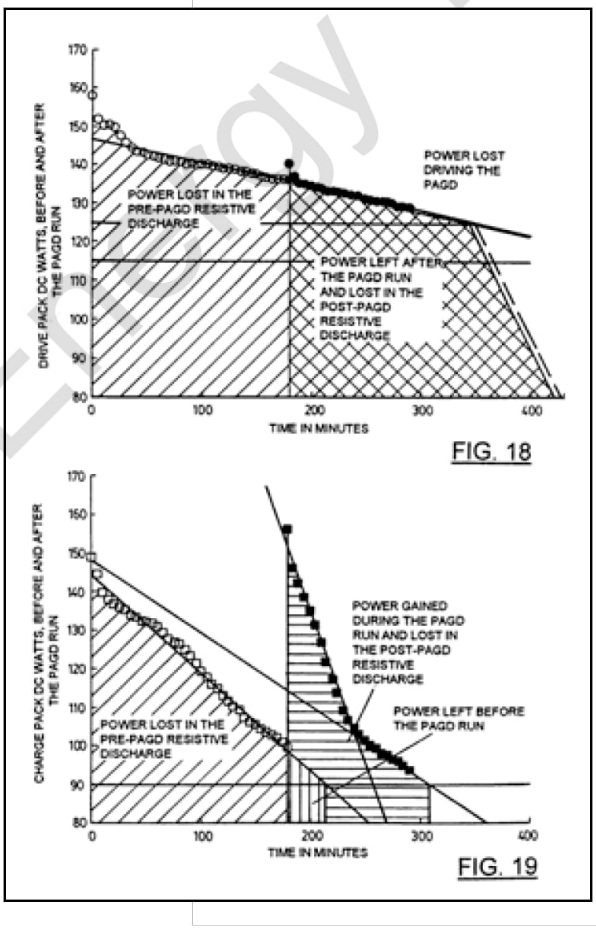

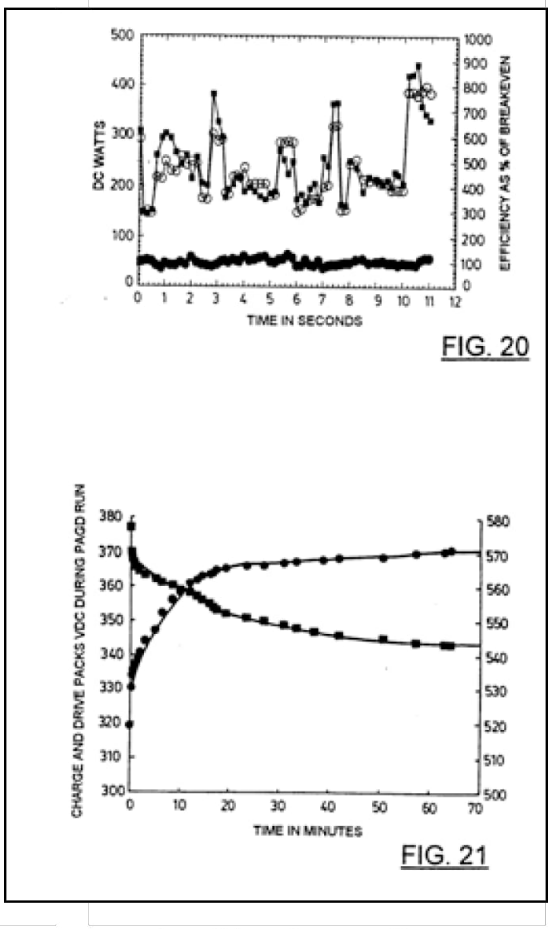

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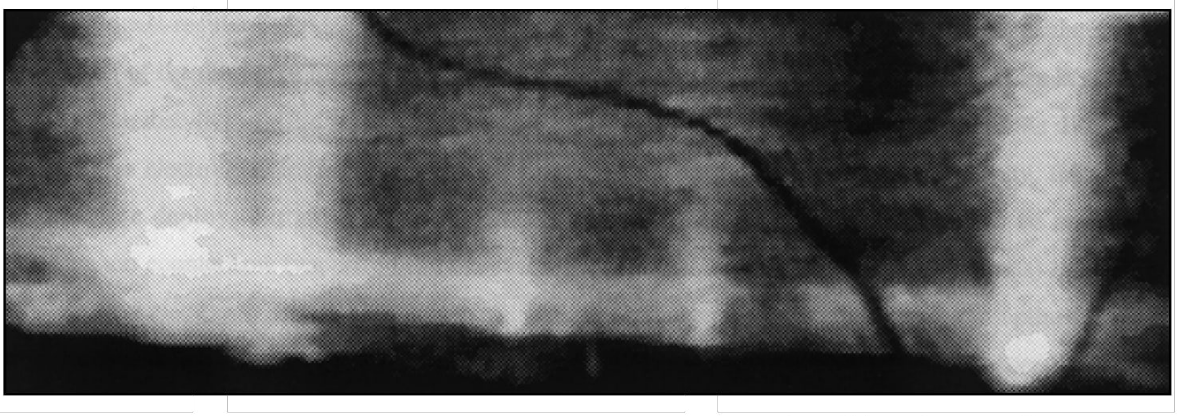
TABLE 8

1 Expt. No.	2 Battery Pack	3 Position	4 Total Wh	5 Rel. Cap.	6 Torr	7 Limit in W	8 ΔkWh gain	8 ΔkWh loss	9 Exptl. time	10 abs. kWh/h gain	10 abs. kWh/h loss	net	f1 BE
1	C	b	159	12%	0.8	90			21.5'			+664	846%
	C	a	428	32%			269			753			
	D	b	1764	85%		115							
	D	a	1732	84%				32			89		
2	C	b	118	9%	0.8	90			18'			+616	2,667%
	C	a	303.5	23%			192			640			
	D	b	542.3	26%		115							
	D	a	535	25.9%				7.3			24		
3	C	b	950.4	72%	0.2	90			70'			+186	3485%
	C	a	1,161	88%			210.9			191.7			
	D	b	660	32%		115							
	D	a	654	32%				6.5			5.6		
4	C	b	15.8	1.2%	0.8	90			64.5'			+53.7	406%
	C	a	81.9	6%			65			60			
	D	b	181	8.7%		115							
	D	a	165	8%				16			14.7		
5	C	b	34.5	2.6%	0.8	90			28.5'			+169.1	436%
	C	a	138.8	10.5%			104.3			219.6			
	D	b	1,114	54%		115							
	D	a	1,089	53%				24			50.5		
6	C	b	55.4	4.2%	0.8	90			74'			+117	483%
	C	a	237.6	18%			182.2			148			
	D	b	669.3	32%		115							
	D	a	631.7	30.6%				37.7			30.6		

1 Expt. No.	2 Battery Pack	3 Position	12 Config.	13 Tube	14 Cathode area	15 gap cm	16 PPS	17 PAGD seq. method	18 R1 ohms	19 Plate material	20	21 C3/C5 mfd	22 C7a/C7b mfd
1	C	b	Triode	A26	128 cm2	5.5	8	Continuous	300	H34		20,700	3.300
	C	a											

TABLE 8-continued

	D	b										
	D	a										
2	C	b	Triode	A26	128 cm2	5.5	61	Interrupted	300	H34	20,700	3,300
	C	a										
	D	b										
	D	a										
3	C	b	Triode	A28	128 cm2	5.5	32	Interrupted	300	H220	34,700	5,500
	C	a										
	D	b										
	D	a										
4	C	b	Triode	A46	64 cm2	4.0	5	Continuous	600	H34	34,700	5,500
	C	a										
	D	b										
	D	a										
5	C	b	Triode	A46	64 cm2	4.0	32	Interrupted	600	H34	34,700	5,500
	C	a										
	D	b										
	D	a										
6	C	b	Plate	A29	128 cm2	5.5	8	Interrupted	300	H220	34,700	5,500
	C	a	Diode									
	D	b										
	D	a										



Shot of a sequence of five PAGD channels in a parallel plate LGEN™ PAGD generator operating at 130 pulses per second and with breakdown fields of 100 V/cm. ©Correa & Correa

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TRITIUM PRODUCTION FROM A LOW VOLTAGE DEUTERIUM DISCHARGE ON PALLADIUM AND OTHER METALS

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ABSTRACT

Over the past year we have been able to demonstrate that a plasma loading method produces an exciting and unexpected amount of tritium from small palladium wires. In contrast to electrochemical hydrogen or deuterium loading of palladium, this method yields a reproducible tritium generation rate when various electrical and physical conditions are met. Small diameter wires (100 - 250 microns) have been used with gas pressures above 200 torr at voltages and currents of about 2000 V at 3-5 A. By carefully controlling the sputtering rate of the wire, runs have been extended to hundreds of hours allowing a significant amount (> 10's nCi) of tritium to accumulate. We will show tritium generation rates for deuterium-palladium foreground runs that are up to 25 times larger than hydrogen-palladium control experiments using materials from the same batch. We will illustrate the difference between batches of annealed palladium and as received palladium from several batches as well as the effect of other metals (Pt, Ni, Nb, Zr, V, W, Hf) to demonstrate that the tritium generation rate can vary greatly from batch to batch.

1. INTRODUCTION

We will report on our tritium generation results from a palladium wire-plate configuration subjected to periodic pulsed deuterium or hydrogen plasma. This configuration is reproducible within a batch and produces a measurable amount of tritium in a few days. As in other work in this area, it has been found that the output is very batch dependent and sensitive to material impurities that prevent hydriding. As in our previous work [1,3], all tritium data was obtained from several batches of 100 or 250 micron wire and 250 micron thick plate from J&M or Goodfellow metals. In these experiments most of the tritium data was obtained with on-line tritium gas monitors. Several times, the gas was oxidized and tested with a scintillation counter.

Some have criticized the detection of tritium because the signals seem to be (a) insignificant, (b) tritium is ubiquitous, and (c) the palladium metal is subject to possible tritium contamination. The magnitude of the signals discussed in this paper are multi-sigma and are sometimes over a hundred times the tritium background in the supply gas. Furthermore, the rate of tritium evolution in the sealed system may be the most sensitive and rapid indicator of anomalous nuclear behavior in deuterided metals. As such, it is well suited for parametric investigations. We will briefly discuss the possible avenues for contamination and show that each is negligible, or not a factor, in the experiments described.

2. MATERIALS

For this work we used Cryogenic Rare Gases deuterium 99.995% that has 90 pCi/l of tritium, and research grade hydrogen with no detectable tritium (< 25 pCi/l). The major impurity in the deuterium is H_2 (0.005%) (He <1ppm). A total of 74.2 g of palladium wire/powder/foil was used in plasma experiments described in this paper. Of that amount, 8.6 g was used in various hydrogen or deuterium control experiments. The palladium has been checked for tritium contamination by two independent methods (heating in hydrogen/deuterium and H_2 plasma).

Much of the palladium has been subjected to rigorous metallographic and impurity analysis. The impurity levels for the wires (Johnson Matthey Puratronic, Goodfellow) varied from the specification sheets and were in the 60-150 ppm range (mostly Cu, Fe, W and P) rather than the quoted values of 5-10 ppm. Most wires were used as received, but several wires were annealed in air (at 850°C for 2 hours) or stress relieved (600°C for 4 minutes) in air. Some of the wires (mostly J&M), when wrapped on a white macor ceramic spool and heated (to 600°C) left brown diffuse deposits (50 cm or more in length) or black diffuse spots (1-3 mm in length). The two batches that showed the most tritium did not yield the black spots but did leave light, small amounts of the brown deposits.

Three batches of palladium were used for the plate, the first batch of 220 micron thick foil was annealed at 850°C for 2 hours at 10^{-6} torr before use. A second batch had a different impurity analysis from the first, but was annealed in a similar manner; the third batch was used as received and had a different impurity level from the first two batches (although, all three plate batches had total impurities in the 350-500 ppm range, mostly Pt, Au, Cu and Fe). Wire from five batches (lots W13918, W06528, Z0114, NM 35680, Z0293, GF5140/6) was obtained from Johnson Matthey and Goodfellow Metals and one length of wire was supplied by Ben Bush. Only the Goodfellow batch and J&M (W13918) showed large (8 to 10^2 nCi) amounts of tritium although the other batches of J&M and Ben Bush wire produced small amounts (~1.5 to 6 nCi total per run).

Tritium contamination in the palladium wire and plate was tested by two independent methods: sputtering of the wire in a hydrogen plasma atmosphere and heating of the wire or plate to either 260 or 800°C in deuterium or hydrogen. No evidence of tritium (to within experimental error ~ 0.3 nCi) contamination was found in the heating experiments with hydrogen. The Goodfellow wire was tested for contamination (with null results ~ 0.3 nCi) by heating to 280°C sections (0.1 g) of wire taken between wire samples shown to produce tritium in the experiments. In our previous work [3] we were able to set a limit of 0.005 nCi/g obtained with ^3He detection of aged palladium samples from a different lot. Also, in an extensive independent [4] investigation of palladium wire, several hundred wire samples were tested and no tritium contamination was detected. The purity of the wire used in these experiments also weighs against, ubiquitous, intrinsic spot contamination, although the appearance of the black and brown deposits indicates that spot and distributed impurities can be present.

3. APPARATUS

Shown in Figure 1 is one of two stainless steel gas analysis loops containing a 1.8 liter ion gauge and a 310.9 cc calibration volume. The atmospheric, ion gauge and sample pressure (0.2%), Femtotech and

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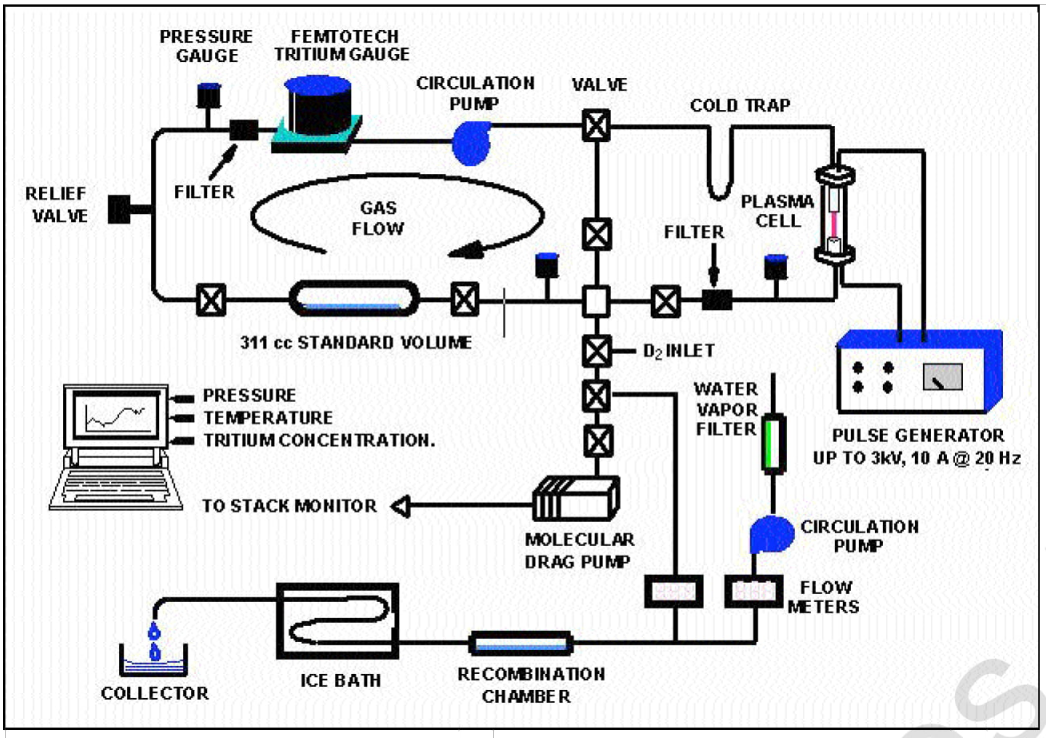

Figure 1 Tritium analysis system used in this study showing the oxidation apparatus.

room temperatures (0.1°C) are recorded on a computer log at 60 s intervals. The pressure drop during hydriding of the wire and plate is used as an approximate indicator of the stoichiometry of the PdD_x. Both loops have a heater to maintain the Femtotech (-0.03 nCi/l°C) at a constant temperature, an integral cold trap, and there are valves that allow the pressurization of the cell independent of the loop. A two micron filter is installed at the inlet of the ion gauge and at the outlet of the cell to eliminate spurious responses due to particulates. To eliminate the possibility of oil contamination, a molecular drag and diaphragm pump is used to evacuate the system.

The Femtotech ion gauge rejects pulse type radioactive events that effectively discriminate against radon and cosmic ray ionization. The initial background drift rate in the Femtotech was 0.002 nCi/h to 0.006 nCi/h, but after exposure to the cells described in the paper, the drift rate increased, and could reach as high as 0.01 nCi/h. In order to return to the baseline rate, it was necessary to clean the loop tubing and Femtotechs halfway through the study.

A hydrogen oxidation system was built as a backup test for tritium using a scintillation counter (Packard 1600). Calibration D_2 gas with 25 nCi/l of tritium was used to test the two Femtotechs and the oxidation system. The two ionization systems agree to within 5% of each other while the scintillation results are within the experimental error (0.3nCi) of the Femtotechs.

The typical arrangement of the cell allows a wire to sit perpendicular to and a few millimeters above a circular plate. In operation, the plasma is adjusted so that it envelopes the whole wire and contacts the plate at a small spot. Typically, the plasma is light blue (D^{2+}) with areas of pink (D^{3+} or D^{+}). At high currents (> 5 A), a bright pink electron channel forms that extends parallel to the wire from the base of the wire to the plate. Initially, the Pd wire is 25 to 30 mm in length and about one mm from the plate. The plate diameter is 3.0 cm or 1.8 cm.

4. PROCEDURE

The procedure for a plasma run was to first fill the 3.1 liter loop with deuterium gas at 600 torr and obtain a measure of the initial background tritium concentration. With the loop drift rate measured, the deuterium was circulated through the cell to slowly hydride the sample. The pressure in the cell and the loop was then lowered to the operating pressure by pumping the excess deuterium out.

The wire was pulsed negatively, at 20 ms at 50 Hz, with currents between 2 and 5 A, voltages that varied from 1500 to 2500 V, and cell pressure of 300 torr. These conditions reduced the heating in the cell and maintained a cell to ambient temperature difference of less than 25°C to avoid gross dehydriding of the wire and plate. It appeared important to avoid a plasma condition that resulted in either a bright pink electron channel or arcing at the tip of the wire. After a few hours of plasma operation the voltage-current stabilized, presumably due to the formation of small cones (10-20 microns high) all over the surface of the wire. After 20 hours, palladium was visibly sputtered onto the plate. The sputter rate at 300 torr, 3.5 A, was about ~2 Angstroms/s. The cell pressure was monitored, and if it did not

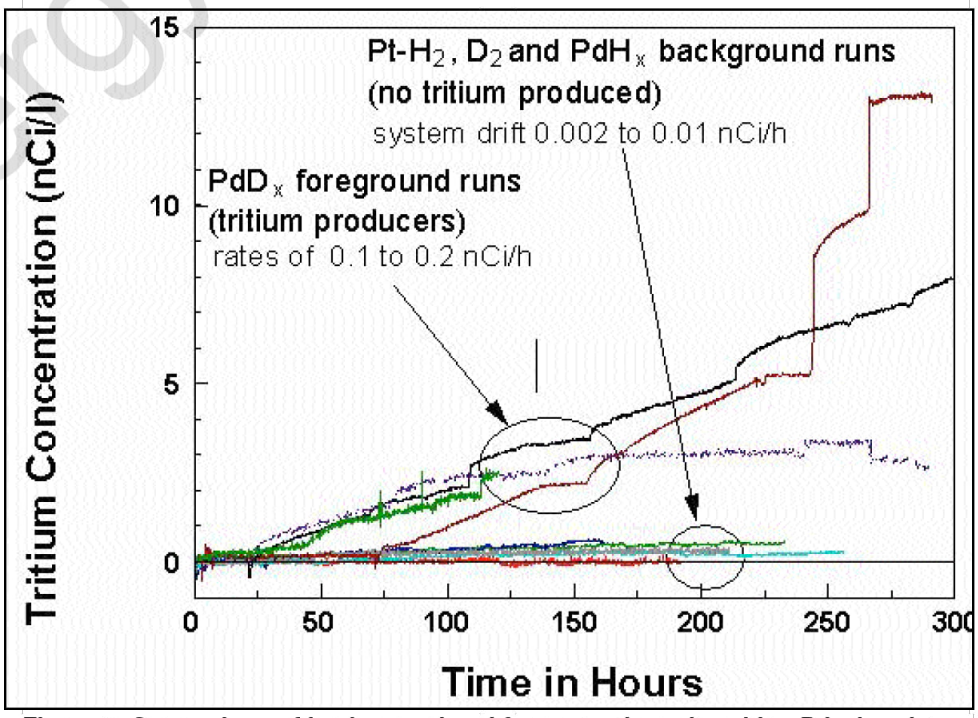

Figure 2. Comparison of background and foreground results with a Pd wire-plate type plasma cell. A Pt wire-plate plasma and a flowing D_2 background is shown for comparison.

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drop after 24 hours (indicating hydriding), then a small amount of CO_2 (0.75% by vol) was added, which would initiate hydriding.

At the end of a run the pressure was increased to 600 torr, the gas was circulated, and the system allowed to equilibrate for about 8 hours. If the reading was steady and CO_2 was added, then the gas was circulated through the liquid nitrogen cold trap to collect any water and determine if any tritiated water was present. The system was then pumped out, the cell closed off, and fresh deuterium added to the system after a couple of flushes with either fresh deuterium or air. The difference between the fresh deuterium and the deuterium reading after exposure to the plasma was used as the measure of the tritium content. In cases where more than 10 nCi were found, the palladium wire and plate were heated separately to over 250°C and the result admitted to the evacuated loop.

5. RESULTS

A total of 65 plasma wire experiments were performed, 12 of these were other than palladium wire and plate. Twenty experiments were run with multiple wires, usually 3 wires bundled together, and eight experiments used different thickness foils 25 to 125 microns thick. The balance of the tests were done with one 250 micron diameter wire and 250 micron thick plate. Three hydrogen plasma experiments were done with palladium plate and wire and two were done with platinum wire and plate. A summary of several background and foreground experiments is shown in Figure 2. The best experiment, produced 10^2 nCi.

Plasma runs 3 and 4 deserve some detailed explanation since these produced the most tritium. First, (see Figure 3) cell 3 was preheated in order to drive off any contaminants. The plasma was then started and the tritium generation rate was 0.15 nCi/h. Near the end of the run, the cell was twice flushed with deuterium, which caused the total tritium (as detected by the Femtotech) to jump up. At the conclusion of the experiment the plate and wire (from plasma 3) were heated, insitu, and released another 5.4 nCi. In order to resolve whether the tritium was originating in the plate or wire, they were separately heated after plasma 4. The wire released about 12.4 nCi of tritium while the plate had no measurable (< 0.3 nCi) release.

A number of Pt and Pd controls were run with D_2 or H_2. Most of these are shown in Figure 2 in comparison with the foreground cells. In general, drift rates with the plasma on were in the 0.004 to 0.01 nCi/h range. Not enough hydrogen and platinum blank experiments have been run to definitely conclude that tritium production is confined to the palladium-deuterium system. We believe, however, that because the hydrogen and non-hydriding metal experiments are low or null, that the rather large results with palladium are unique. We also ran several hydride forming metals other than palladium. In the case of Hf and Zr it was difficult to maintain the plasma, so for most of the run the background drift rate is similar to the cell with D_2 circulating (<0.003nCi/h). Tungsten, vanadium, niobium, and nickel-deuterium were on for about 100 hours, but their rates were still very close to background (0.007 to 0.009 nCi/h). Romodanov [5] et. al. reported that Nb was more active than W, Zr, Ta or Mo in their gas discharge experiments. We also found small amounts of tritium in niobium (1.1 nCi), and observed a small rate with nickel-hydrogen (0.012 nCi/h). Both of these samples deserve further investigation.

The wire-plate plasma experiments have been very consistent but also very dependent on the exact batch of palladium that was used. We found that the batch, material and material condition are critical parameters. Our first batch of GF5140/6, for example, had an average rate of 0.4 nCi/h, with several rates greater than 0.1 nCi/h. Our second best results came from an arrangement with the second batch of the same wire in which three wires were bundled together. Their rates varied from 0.02 to 0.07 nCi/h.

At the conclusion of two of the experiments, about a third of the deuterium was oxidized and the heavy water and a control were submitted for scintillation counting. The results were 3400 to 213 dpm/ml and were in agreement (within experimental error) with the tritium activity calculated from the drop in reading of the Femtotech. Background activity from the D_2 gas prepared by this method is about 39 dpm/ml.

6. DISCUSSION

The basic premise that the detected ionizing material is tritium is indisputable because, (a) quantitative measurements agree with the scintillation counter, (b) the gas may be transported on a clean palladium bed between different ionization systems and produces an increased reading commensurate with the decrease in tritium concentratio noted in the initial system, (c) as the pressure is decreased the tritium signal is seen to decrease (for dry gas) in a manner consistent with the calibration for a known level of tritium in deuterium and finally, (d) the signal shows no diminution over a two week time period, consistent with the half life of tritium.

Three types of contamination of the wire are possible; the first is just surface contamination due to atmospheric or liquid exposure to tritium, the second type might be a distributed impurity, and the third would be a spot contamination. To avoid surface contamination, we thoroughly clean and polish the palladium surface prior to each run. If it were still present, a surface contaminant would be immediately evident when the wire was introduced to the analysis loop and deuterided, but we have not seen evidence for this type of contamination. We attribute the residue and smoke seen from some of the wires to entrained lubricant due to drawing the wire. This lubricant tends to be drawn out and smeared throughout the length of the wire, which implies tritium contaminated oil should be detected in long sections of the wire. However, wires that showed obvious high levels of oil contamination did not show tritium, and we did not observe a large tritium signal when the wire was heated and the oil suddenly evolved. Similarly, the dark spots are present after simply heating the wire to 600°C but there is no evidence for tritium release at temperatures as high as 850°C.

An indicator that the tritium originated in the cells is that the output was sensitive to the metallurgical condition of the palladium. Palladium wire annealed in air showed a lower output than as received wire. Likewise palladium wire stress relieved but not annealed showed a similar (about a factor of 3) reduction in output. This could be interpreted as a release of tritium if it was contamination, however, then the tritium would have been easily detected in the heating controls. In sample #4, that showed significant tritium output, post heating (250°C) of the palladium wire released 12.4nCi of tritium. This amount of tritium would have been easily detected in the heating control of the same spool of wire (10 cm) taken from the next section of material. Furthermore, the tritium in the gas evolved from the wire during the post heating at 250°C was far (5340 nCi/l) above the equilibrium tritium concentration (31.4 nCi/l) in the gas after the run. The fact that such high concentrations can be left in the palladium suggests that the process is near but not at the surface. The pulse length is sufficient for the diffusion of 200 Angstroms (10 ms pulse length) into the palladium. Then the tritium may be released when the surface layer of the palladium is sputtered by the energetic

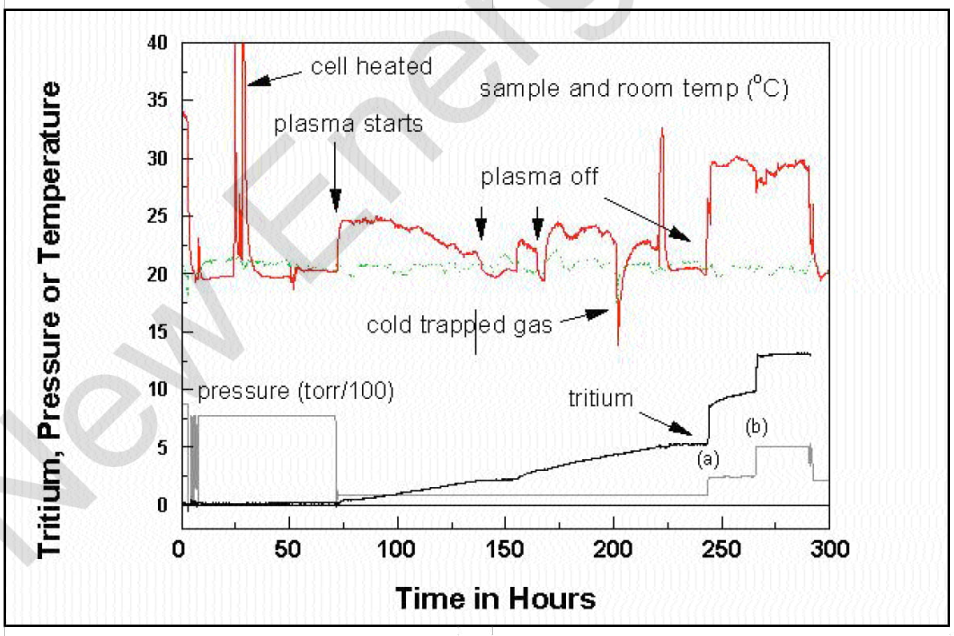

Figure 3. The cell temperature, ambient temperature, tritium concentration and pressure plotted to illustrate the operation of cell 3. When the sample temperature and the ambient temperature are close, the cell is off and the tritium concentration remains constant. When the cell drops below ambient temperature, the cold trap is activated; no significant decrease in tritium level was noticed.

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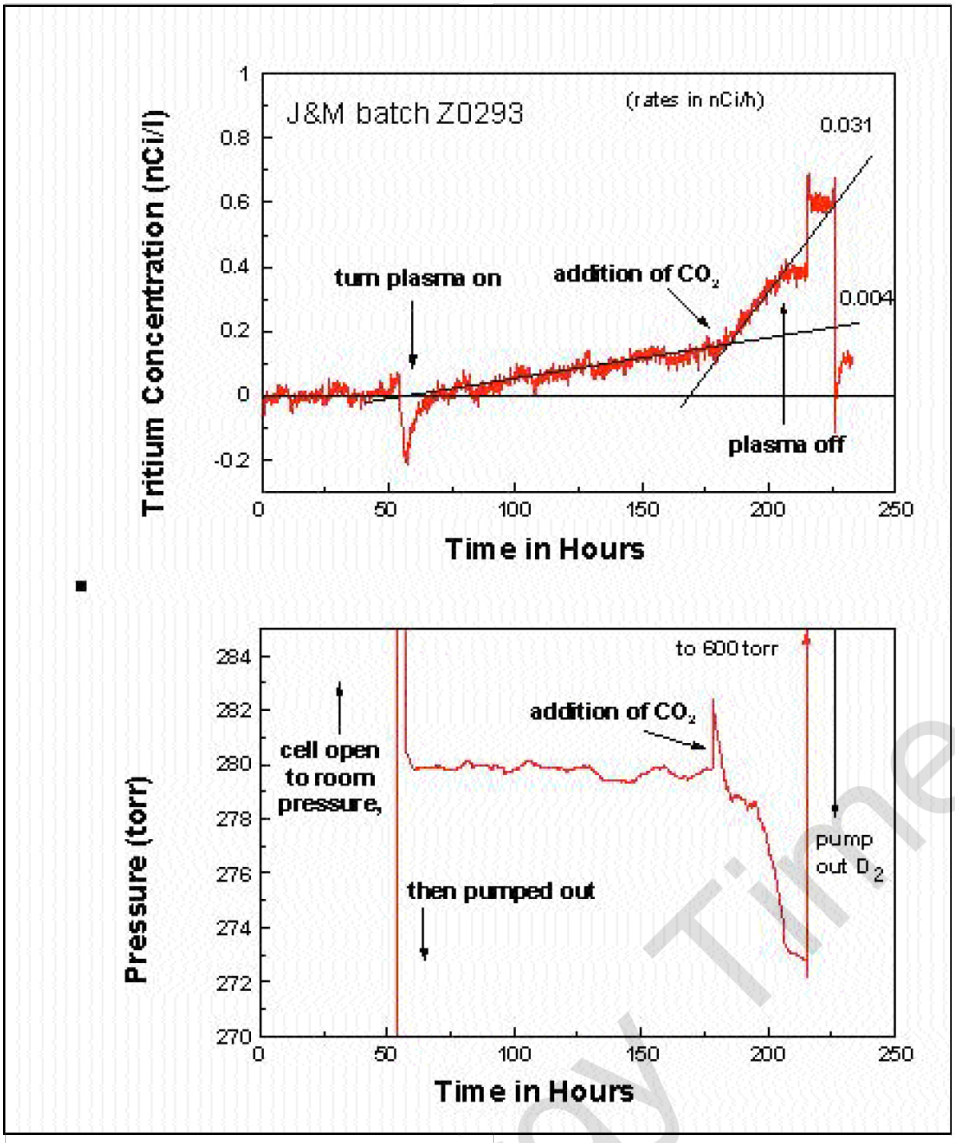

Figure 4. Tritium output from a cell that appeared to be a non-producer until 2 torr CO_2 was added to the deuterium. This caused the plate (and perhaps the wire) to hydride and a coincident rise in the tritium generation rate by nearly a factor of 7 was observed until the wire bent away from the plate.

plasma. This would indicate that the tritium was in a 15 to 30 micron layer on the 250 micron in diameter wire. The fact that a significant amount of tritium shows up as (after the addition of CO_2) TDO is also indicative of a near surface reaction. Dendrites and aspirates (up to 20 microns high) on the surface of the palladium have been suggested [2] as possible tritium formation sites.

When palladium is hydrided it is stressed and, to some extent, work hardened. The wires after hydriding have always shown an increase in grain growth (to 50-100 microns) from the very fine (1-2 microns) microstructure initially observed with these materials. The observed reduction in stress relieved wires indicates that the dislocation density must play a very important role in the tritium production. However, since all as received wires were hard drawn but not all batches of wire showed production, there are other factors that are important, such as the purity and the hydriding.

The purity of the material varies from batch to batch, and within a batch sections of the wire are cleaner than other sections. Thus it could be that the lack of oil, iron or hydrogen impurities is critical or that there has to be an another atomic species present. We believe that the lack of oil or other impurities is important to help the material hydride efficiently. The key mechanism, however, may be associated with another impurity species that need be present only at the sub ppm level at the dislocations.

The importance of hydriding the palladium can be clearly observed in a plot (Figure 4) of tritium output versus time for a sample from batch Z0293 that weakly hydrided. The tritium evolution rate was at the background drift rate (0.004 nCi/l). When (0.75% by vol) CO_2 was added to the system the tritium rate increased to a rate some 7.7 times the background drift rate. Coincident with the tritium increase, the deuterium pressure dropped indicating the palladium plate was hydriding. This decrease in pressure is more than can be accounted for if the CO_2 is totally converted to D_2O. We confirmed this with a platinum control cell in which the pressure only decreased by 2 torr. In another experiment where the pressure immediately dropped, indicating that the palladium had initially hydrided, the tritium generation rate was ~0.02 nCi/h and an addition of CO_2 did not change the rate of tritium production.

The CO_2 may also make it feasible to run at lower pressures where a high loading is more difficult to achieve. An analysis of the ratio of tritiated water to tritium in the gas reveals that most (70%) of the tritium remains in the gas. Additions of CO_2 to Pt runs neither change the rate of drift (tritium) or exhibit large pressure decreases as shown in Figure 4. The CO_2 and CO that is produced within the cell are known to be surface poisons that normally would not allow the palladium to hydride. However, in the presence of a reactive energetic plasma the surface is cleaned of these materials and deuterium is allowed to disassociate on the surface and diffuse in. When the plasma ceases, the surface poison reabsorbs inhibiting deuterium from recombining on the surface.

7. CONCLUSIONS

We have found that the tritium output depends on the temperature, pressure and current applied to the cells. Yet, the tritium yield is most sensitive to the purity and metallurgical condition of palladium used in the experiments. Various tests for tritium contamination confirm that there is no initial tritium contamination in the powder, foil, wire or other materials used in this study. CO_2 additions had a remarkable effect on the production of tritium by these cells and the effect seems to be related to and enhancement of the hydriding of the palladium.

It appears that very pure palladium is more effective than impure palladium in producing tritium. Based on our impurity analysis of the material we cannot identify a difference in concentration of a single impurity that is important to either include or exclude from the palladium. This is partially a morphological or metallurgical issue involving dislocations since we have seen a reduced output from annealed or stress relieved palladium when compared to as received palladium from the same batch. However, palladium that has been hydrided and dehydrided must always be annealed to reactivate it. The fact that most of the tritium is evolved promptly to the gas, yet significant amounts are found in the palladium suggest that the process is near but probably not at the surface.

8. ACKNOWLEDGMENTS

Many people were involved in a direct way with the experiments described here. Some of these were Ken Griechen, Roy Strandberg and Kane Fisher who were instrumental in the design and construction of the first few cells. Joe Thompson counted our tritiated water samples. Mike Hiskey and William Hutchinson were helpful in the analysis of contaminants in the vacuum system and on the samples.

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U.S. Cold Fusion Company Signs $25,000,000 Contract for Mainland China Project

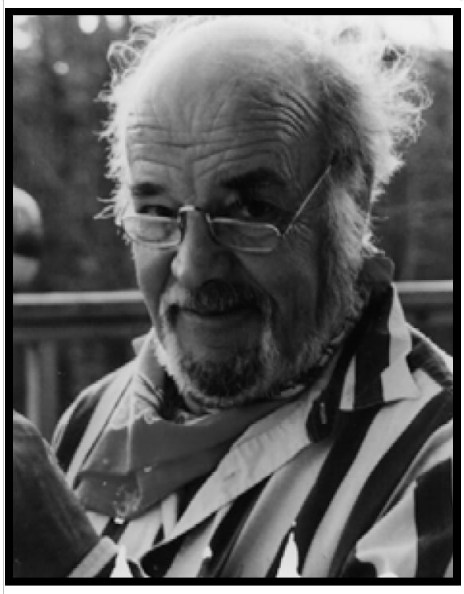
NOVA RESOURCES GROUP, INC.
PRESS RELEASE
JUNE 9, 1996

DENVER -- Nova Resources Group, Inc. (NRG) announced in May the signing, after two years of negotiations, of a $25,000,000 contract for the right to manufacture NRG's cold fusion power generation technologies within the Peoples Republic of China. The contract establishes Philadelphia-based **MacroLabs** (a subsidiary of **MicroLabs, Inc.**) as the master licensee for mainland China. The flat-fee contract amount is payable in annual installments of $2,500,000 for ten years, commencing upon successful demonstration of NRG's cold fusion power generating modules.

These power modules will be based on NRG's 20kW (therrnal capacity) pressurized research reactor, the ETC (Electrolytic Thermal Cell), using its interchangeable electrochemical cartridges to develop reactions of the required power, temperature, and duration. The cartridges contain all constituents that might suffer wear or be consumed during energy production, and will simplify refueling when in service. Among other advantages that this approach confers is that improvements in reaction processes can be moved quickly from the lab into field use, during the next refueling cycle. NRG will promptly pay royalties to researchers who use NRG research apparatus to develop these improved processes and who post their results and procedures to an Internet site established for that purpose.

Heat produced in the reactor core (or clusters of cores) by the reactions within the cartridges will boil a pressurized coolant (working fluid). The resulting hot vapor will spin a turbine coupled to a high-speed alternator, making electricity. The vapor exiting the turbine is recondensed and pumped back to the boiler. This thermodynamic cycle, the Rankine cycle, is used in nearly all present fossil and nuclear generating stations. Effectively, NRG plans to scale-down the rest of the power plant to the size of the laboratory reactors, instead of attempting to scale-up the reactions. Bypassing scale-up permits rapid commercialization of cold fusion power by the mass-production of reliable, refrigerator sized, sealed units. This production plan also fits well with the manufacturing capabilities and infrastructure of developing nations such as the Peoples Republic of China

The turbo-alternator and embedded system controller (T/A} are not a part of the license package. The football-sized T/A sub-assemblies will be manufactured by NRG and supplied to its licensees. The control-system computers in each T/A submodule will perform quality-assurance acceptance tests when the T/A is installed within the licensee reactor system and will report back to NRG via a fiber optic port (also used for software "firmware"- updates). The onboard system controller, as well as operating the cold fusion reaction and Rankine cycle, will also supervise the electrical power interface with any other systems on a grid of any size. It is this synchronous power synthesis capabilty which will allow the NRG sytem to supplement, eventually supplanting, large scale power sources.



Obituary
Christopher Bird (1928-1996)

Christopher Bird 68, best-selling author, naturalist, humanitarian, and researcher of anomalous phenomena and science, died of a stroke suffered at his home in Blairsville, Georgia, Thursday, May 2nd, 1996.

Mr. Bird's best-known book, *The Secret Life of Plants*, which he co-authored with Peter Tompkins, became a long-running best-seller, and added a new dimension to the environmental movement, begun by Rachel Carson's *Silent Spring*. Its premise, that plants had some measure of consciousness and an awareness of the world around them, caused intense controversy in science and a popular revolution in the way in which people regarded plants. The idea of talking to one's plants became a staple of conversation, as well as a source of humor and levity. Still in print, *The Secret Life of Plants*, was translated into 15 languages and was followed in 1979, by *The Divining Hand*, recognized as the definitive book on the ancient practice and history of dowsing, and in 1991 by *Secrets of the Soil*, also co-authored with Peter Tompkins, and is considered by many to be one of the most important books ever written on organic farming, gardening, and soil management. Many of the once controversial implications of *The Secret Life of Plants*, and *Secrets of the Soil* are now accepted foundations of the organic farming and gardening movement. His experience of being attacked, often in highly personal tones, by mainstream sciences led Mr. Bird to spend the later years of this life exploring the question of how science deals with the apparently anomalous. In 1993, he wrote *The Trial and Persecution of Gaston Naessens,* concerning the trial and acquittal of Canadian biologist Gaston Naessens over his unorthodox cancer research. At the time of his death, Mr. Bird was completing a book on water.

Mr. Bird, scion of one Massachusetts' oldest families, came by his interest in nature through his forefathers—the Birds donated their extensive holdings on Chappaquidick Island to the Commonwealth of Massachusetts to create a wildlife sanctuary, and their estate in East Walpole was recognized for its variety of trees and flora. He was also a gifted linguist, and these two interests were reflected from the earliest days of his education. He attended Milton Academy and Harvard College, where he took a degree in Botany with a minor in Chinese. On his own he taught himself Russian by living with a Russian emigre family. In pursuit of research for his many books and articles, he traveled the world over, and was also fluent in French, Spanish, Chinese, Japanese, and Serbo-Croatian. After leaving Harvard, he was awarded a Masters Degree in Eastern European Studies from American University in Washington, D.C.

In 1952, Bird was recruited by the Central Intelligence Agency and sent to Japan. After leaving the CIA, he volunteered for the Army, where in 1955, he was one of the first 50 American soldiers sent to Vietnam, as part of an elite Special Forces unit. After leaving the service, Mr. Bird undertook further graduate studies in anthropology at the University of Hawaii, while also working as a reporter for the *Honolulu Advertiser*. Returning to Washington, D.C, in 1957, he translated Russian novelist Nikolai Narokov's *Imaginary Quantities* into English; it was published in the U.S. in 1958 as *The Chains of Fear*. Mr. Bird then went to work for the Rand Corporation in Santa Monica, California as the Special Assistant to James Rand, and later headed the Washington, DC office of the Rand Corporation. In 1966, he became foreign correspondent for *Time Magazine* in Yugoslavia. Upon returning from Yugoslavia in 1968, he met Mr. Tompkins, who played a prominent role in the OSS during World War II, and who was also a linguist and writer. Common backgrounds and shared interests led first to friendship and, then, their decades long collaboration which included extensive research on the life and work of Wilhelm Reich.

Mr. Bird's involvement in many civic and professional organizations included, with his longtime friend the late Arthur Young, the Institute for the Study of Consciousness, and the American Society of Dowsers of Danville, Vermont, which he served as Trustee and the international editor of *The American Dowser*. At the time of his death Mr. Bird was Vice Chairman of the Riess Institute of Washington, DC, which he co-founded in 1983.

Christopher Bird is survived by his wife Shabari, and four daughters, Kristina, Lehua, Doina, and Zvia, from his first rnarriage; a step-son Tim Bunge from his second marriage; as well as two brothers, an identical twin, Mr. David Bird, of Cambridge, Massachusetts, and Mr. Charles Sumner Bird, III, of Aiken, South Carolina. A delayed memorial service is being planned for late August to allow family members and friends to attend.

Chris Bird was also a good friend and advocate of this magazine. The Editor had many memorable exchanges with him about water, science, and life. Chris Bird will be sorely missed.
— Eugene Mallove

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Uncanny and Disquieting Historical Parallels— Will the Hot Fusion Program Last 203 Years?

Longitude* – *The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time
by Dava Sobel (Walker, 1995) 183 pages.

Revolution In Time* – *Clocks and the Making of the Modern World
by David S. Landes (Harvard University Press, 1983) 482 pages.

Books reviewed by Jed Rothwell

Good news! Short books, long subtitles, and heroic history are back in style. *Longitude* made the best seller list, where you seldom see a serious book about the history of science. It is a beautifully written little book about John Harrison, the first person to make an accurate chronometer. This is a clock set to Greenwich Mean Time (GMT). It is used with a sextant to determine longitude. Harrison is portrayed as the archetypal lone genius, a self-taught man of humble origins, a man with a better idea who battled the establishment for decades. It took him 36 years of hard work to make four prototype clocks. His invention saved thousands of ships and countless lives, but his rivals fought to prevent him from collecting the £20,000 reward established by Parliament (worth approximately $12 million today). Finally, King George III intervened in his case and saw to it that justice was done. *Revolution in Time* describes the broader history of horology and its effects on society up to the present day, with three chapters devoted to Harrison and the chronometer. Longitude is an inspiring story about a courageous individual who made a giant leap forward and a pot of money too. Most people in the cold fusion business would love to see themselves in this heroic pose. We hope things come out this well for us. We can learn many lessons from Harrison's triumph as well as his mistakes and his personality defects. Some of this history bears an uncanny similarity to cold fusion, particularly its sordid aspects. It raises fascinating questions about how new technology develops, who is at fault when it is delayed, and what role government ought to play in the process.

Some of this history bears an uncanny similarity to cold fusion, particularly its sordid aspects...

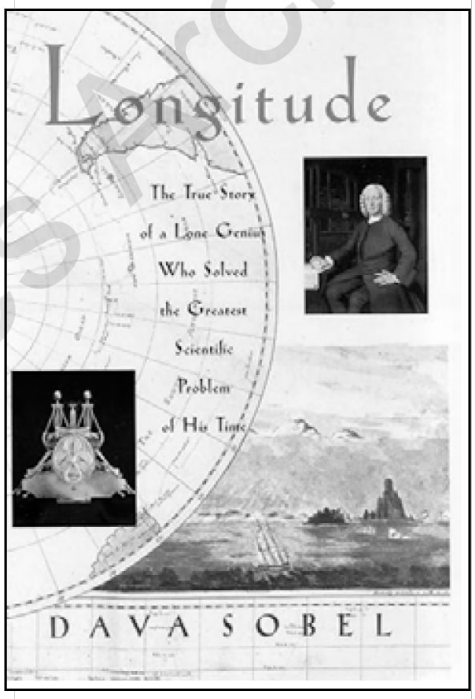
Sobel sums up the story in the first chapter: [1]

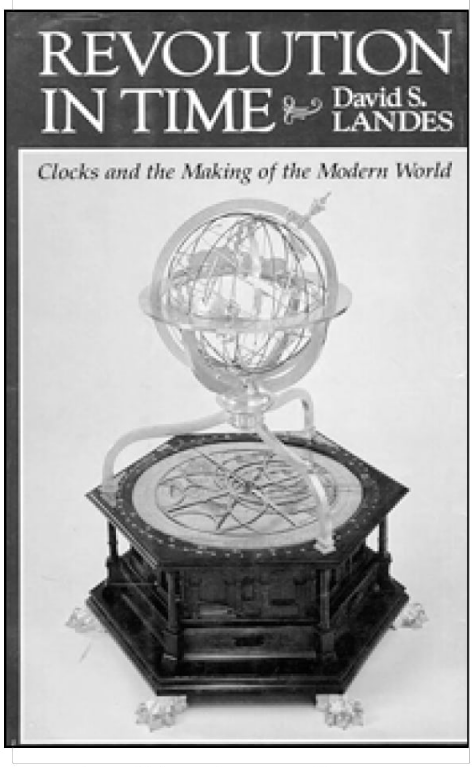
Harrison, a man of simple birth and high intelligence, crossed swords with the leading lights of his day. He made a special enemy of the Reverend Nevil Maskelyne, the fifth astronomer royal, who contested his claim to the coveted prize money, and whose tactics at certain junctures can only be described as foul play.

With no formal education or apprenticeship to any watchmaker, Harrison nevertheless constructed a series of virtually friction-free clocks that required no lubrication and no cleaning, that were made from materials impervious to rust, and that kept their moving parts perfectly balanced in relation to one another, regardless of how the world pitched or tossed about them. He did away with the pendulum, and he combined different metals inside his works in such a way that when one component expanded or contracted with changes in temperature, the other counteracted the change and kept the clock's rate constant.

His every success, however, was parried by members of the scientific elite, who distrusted Harrison's magic box. The commissioners charged with awarding the longitude prize – Nevil Maskelyne among them – changed the contest rules whenever they saw fit, so as to favor the chances of astronomers over the likes of Harrison and his fellow "mechanics." But the utility and accuracy of Harrison's approach triumphed in the end. His followers shepherded Harrison's intricate, exquisite invention through the design modifications that enabled it to be mass produced and enjoy wide use.

This is how it happened, by all accounts. Encyclopedias and books on horology and navigation agree that Harrison invented





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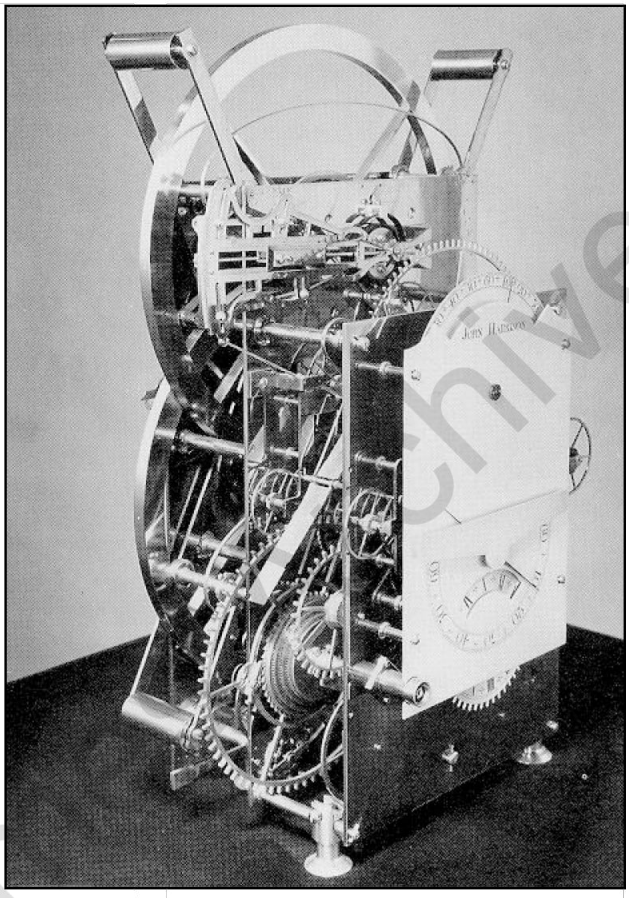
"the first accurate marine chronometer."[2] This description must be carefully worded: other people invented the first practical chronometers; and the first cost-effective ones; and the first that could be mass produced. Harrison never got close to those goals. His first three machines were never reproduced, and two were never even tested at sea. Landes explains:[3]

> . . . it will come as a surprise to learn that Harrison's sea clocks, for all their art and precision, are not the ancestors of the modern marine chronometer. Of Harrison's many ingenious inventions, only the maintaining power . . . has been retained in later mechanisms. The rest were superseded by simpler mechanisms. His contributions, then, lay not in his devices but in the simple fact of their effectiveness: he demonstrated that the job could be done.

Harrison demonstrated a proof of principle machine. Clocks had been used aboard ships to a limited extent, but none were accurate enough to depend on for a long voyage. Isaac Newton and other leading experts concluded that no clock would ever keep time at sea well enough to dispense with lunar time measurements. Newton himself pointed out that you need a clock with the lunar method to record the time of observation.[4] It must be accurate to within a few minutes per day for this purpose. Harrison proved that a clock could be kept within a fraction of a second per day. This meant that a clock alone could do the job without resorting to lunar observations. Pendulum clocks had reached this level of precision by 1715, but a pendulum swings wildly aboard a ship at sea. Harrison gave the chronometer credibility for the first time, just as Pons and Fleischmann gave table-top fusion credibility. His academic opponents dismissed the performance of his clock as a fluke, but expert horologists woke up and realized that navigation by clock was possible after all. Harrison's machines had many parts, and they required years of skilled labor to assemble. They were a tour de force, not a practical solution to the problem. The first three machines (H-1, H-2 and H-3) represented a technological dead end. They did set a high standard of precision, and what is more important, they defined which problems needed to be solved: friction, thermal expansion of components, consistent steady power delivery from the mainspring even when it is tightly wound, and so on. They inspired other machines with radically different designs, including Harrison's fourth (H-4). Harrison's first three machines resembled the electronic computer ENIAC (Eckert and Mauchly, 1946), an impractical machine that took heroic measures to build and operate. ENIAC is usually considered one of the first computers even though it was programmed by plugging in cables instead of a stored program. It was obsolete before it was finished, and nothing like it was ever built again, but it was a big step toward the programmable digital electronic computer.

Someone should build a proof-of-principle cold fusion motor, similar to the H-1 - H-3 clocks. Even if it is impractical and it requires heroic measures to operate, the motor will prove that the thing can be done, and it will map out the design problem space.



Harrison's H-3 Machine

Did Harrison invent it? Does anyone ever invent anything?

Harrison's clocks were never replicated. Successful chronometers were based on different designs. So it is reasonable to ask in what sense did Harrison "invent" the chronometer. Sobel deals with this ambiguity, and after due consideration nominates him the preeminent inventor. Others say that Pierre Le Roy should be considered the true inventor. The issue can never be settled. Technological inventions are not like scientific discoveries. An individual like Newton, Darwin or Einstein can discover something novel in science, and the discovery belongs to him alone, even when he stands on the shoulders of giants. Invention is more of a continuum, like the change from spring into summer, with no beginning, no end, and surprisingly few clear turning points. The textbooks list an invention, a person and a date, but this is an artificial construct. It is like trying to decide who was the first impressionist painter. There are a few clear-cut examples of breakthroughs made by one person or one small group – the X-ray (Roentgen, 1895) and the airplane (Wright brothers, 1903) come to mind – but most major technological discoveries evolved slowly with contributions from many people. The first photographs were made in the 1720s. They were laboratory curiosities that faded after a few minutes. It was not until the 1830s that Talbot and Daguerre independently invented ways to fix the images. Watt (1736-1819) contributed more to the steam engine than anyone else. But the first commercial steam engines were operating profitably 40 years before he was born (Savory, 1698; Newcomen, 1712), and developments in Watt's lifetime outstripped his predictions of the limits of the technology. Edison made giant contributions to the incandescent light, and he introduced the first commercial lights in 1878, but other people had been experimenting with incandescent lights since the 1850s. Things are often invented by different people independently. Famous examples include the incandescent light (Edison and Swan), and the telephone (Bell and Gray). In this field we have the pendulum (Galileo and Huygens), the sextant (Hadley, Godfrey, Halley, Hooke and Newton – the latter two never bothered showing anyone the design), and the balance spring replacement for the pendulum in chronometers (Huygens and Hooke).

The continuum of technology often makes patent law and academic priority artificial constructs. Endless debates arise about who discovered what first. The real answer is often that many people worked on the problem and they all deserve some credit for the solution. In horology there have been many disputes, beginning with Huygens and Hooke, who fought like cats and dogs over the patent for the balance

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spring. This disrupted so many meetings that the Royal Society finally ruled the issue would be dropped from the minutes. The Arnold versus Earnshaw battle over the spring detent escapement has been going on unabated since the 1780s. People will probably argue about it for centuries to come, the way Civil War buffs debate Lee's tactics at Gettysburg. The important question is not who invented the spring detent escapement, but who did a better job manufacturing it; who used it to good effect in the marketplace; and who saved the lives of thousands of mariners by making cheap and reliable chronometers with it. (Earnshaw did, although Arnold was no slouch.) Arnold and Earnshaw devoted much effort to filing suits and publishing pamphlets accusing one another of plagiarism. If they had devoted that effort to business instead, they would have made more money and saved more lives. To its credit, the Board of Longitude rewarded them with £3,000 each. These clock makers, who were on the cutting edge of technology, were contentious, single-minded, obstinate prima donnas, like today's hot Internet programmers, or cold fusion scientists. New technology attracts such people.

Cold fusion was primarily discovered by Pons and Fleischmann, but as Fleischmann pointed out, their ideas were based partly on the work of Cohen.[5] Paneth and Peters attempted to fuse deuterium in palladium with gas loading, and Tandberg tried electrochemistry.[6] It is not clear whether Fleischmann knew about Tandberg, and it does not matter. Tandberg failed, Pons and Fleischmann succeeded. They got copious energy releases. They did a much better experiment. Their gadget worked, and they were replicated. I have no doubt that when the final history of cold fusion is written, they will get the lion's share of the credit, just as Harrison gets the credit for the chronometer. However, the method of producing cold fusion they discovered, with palladium and heavy water, may resemble Harrison's first three clocks: it may be a precursor that never reaches the market.

The case for Le Roy

Many experts think that Pierre Le Roy deserves as much credit as Harrison. Le Roy himself said so at every opportunity. Rupert Gould, who spent 12 years restoring Harrison's four famous clocks, considered Le Roy "the greatest horological genius who ever lived."[7] Gould's reasons for selecting him are instructive. People who want to go down in history as the greatest cold fusion scientists should note what Le Roy did, in contrast to Harrison.

1. He studied other people's work carefully, including Harrison's, which he admired. He had enough humility to acknowledge other people's superiority in some areas, and to learn from them. A little humility would do wonders in cold fusion.

2. Le Roy invented three essential components that were used in all subsequent mechanical chronometers. Harrison contributed only one. Harrison mapped out various improvements, but Le Roy and others implemented them in a practical form.

3. Le Roy had a deep understanding of the fundamentals of physics and horology. So did Harrison, but Le Roy had a more rigorous education, and he was able to express his ideas better. Harrison was self-taught.

4. Le Roy's designs addressed practical necessities. He made his clock with fewer moving parts than Harrison's, fewer teeth per wheel, fewer leaves per pinion, and so on. He wrote: "Nothing can be too simple in a machine for sea purposes, and to be transported into all places and climates." He felt it was essential to make a clock that could be easily copied, something that apparently never crossed Harrison's mind. He wrote:[8]

> All this I think equally favorable to [my watches'] solidity and their easy execution; two things of great moment in making up these instruments, which in order to come into general use should be executed and set to rights, if not by every workman, at least however by the generality of such, whose talents are a little above the common sort.

5. He published his ideas in widely read books, written in "a most lucid style" (Gould). Harrison, in contrast, was notorious for his indecipherable run-on prose and possessive secrecy. The Board of Longitude had to pry his secrets out of him, with years of threats and cajoling.

Why Others Failed

After Harrison showed the way, others horologists tried to follow. Many failed for the reasons listed above: inability or unwillingness to learn from others, ego. Others failed because they were too skilled. Landes explains:

> In 1771 Mudge gave up making civilian watches for ordinary customers and chose to devote the rest of his life to the production of a marine chronometer. He turned out three, like Harrison using a special, idiosyncratic version of the verge escapement. It was the wrong tack to take. Mudge's chronometers performed well, because everything he made performed well. But they were costly to make, hard to copy, and over time did not match the precision cum reliability of Earnshaw's spring detents. Who is to say why Mudge persisted in what proved to be a dead end? My own feeling is that like other great artists – Ferdinand Berthoud and John Arnold, for example – he was a victim of his own prowess. He felt that he could do whatever he wanted, that no task was too difficult for his skill and ingenuity, and he did not find it in him simply to change his approach and work along an apparently successful line invented by someone else.

Many cold fusion scientists are too skilled for their own good. Some of the well-funded ones suffer from having too much equipment, which is too precise, requiring too much calibration, attention and tender loving care. Many cold fusion scientists persist in what appears to me to be the dead end approach of using bulk palladium in heavy water, instead of nickel, thin film palladium, or palladium black.

Horologists versus Astronomers – A 203-year-long Hot Fusion Program

Finding the longitude was, as Sobel puts it, the Greatest Scientific Problem of the 18th century, much as solving the energy crisis is today. This was widely recognized. Leading scientists including Galileo, Newton and Halley worked toward finding a solution. Latitude could be measured with precision, but there was no reliable way of knowing how far east or west you were. This caused countless delays and shipwrecks. In 1707, four Royal Navy ships got lost and ran aground on the Scilly Islands, southwest of England. Nearly 2,000 men were killed. This spurred shipowners and the Navy to put pressure on Parliament, which in 1714 established a £20,000 reward and a Board of Longitude to administer it. The Board included the astronomer royal, the president of the Royal Society (Newton, at that time), the First Lord of the Admiralty, the Speaker of the House of Commons, and so on. Hundreds of proposals were submitted to the Board, including crackpot ideas and sane but impossible ideas like anchoring ships at sea and having them shoot rockets in the air. The serious proposals fell in two categories, chronometer and astronomical time keeping. Both had the

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same goal: keeping track of the time in the home port. If you know what time it is in Greenwich (or Paris, Boston, or any other location), and you see that the sun has reached its highest point locally, you can compare the time difference to determine how far east or west of Greenwich you are. Both methods had merit, and both were eventually perfected, but in the long run the chronometer proved easier to master, faster, and more accurate. Most establishment scientists favored the astronomical methods, while Harrison and some other horologists championed the chronometer. The establishment scientists perfected the astronomical method by the late 1700s in a giant internationally coordinated research project. They continued the project for 203 years, from 1714 to 1917, publishing reams of astronomical data that was of little use after the chronometer was perfected.

In 1610, Galileo found the first effective astronomical clock: the moons of Jupiter. They are eclipsed more than a thousand times annually, at precisely predictable times. He realized they could be used to determine longitude, and he submitted this idea to King Philip III of Spain, who had offered a prize for an effective method. Philip, like the Board of Longitude 100 years later, had been swamped with crank proposals and marginal ideas. His staff rejected Galileo's idea because they thought that a sailor on a rolling, pitching ship at sea could not make careful observations of Jupiter with a 17th century telescope. They were right, but astronomers on land could make such observations, and they did, and they soon began redrawing maps all over the world.

The moons of Jupiter were too small and far away to observe aboard a ship, so the next obvious candidate was the earth's moon. A person standing in Greenwich will see the moon occlude a given star at the same moment as a person on a ship in the middle of the Atlantic. (The observer in the Atlantic sees both the moon and the star lower in the sky.) So if you can predict the exact path of the moon and the time in Greenwich when it will occlude selected bright stars, you can use it as a clock. You know what time it is locally by observing the angle of the moon or the sun. You could keep track of local time reasonably well by setting a spring driven clock every day, as Newton recommended. By the late 17th century, such clocks were dependable to within a few minutes a day, which was good enough for this purpose. After a few days, a clock alone would become useless, because voyages took weeks or months, and a cumulative error of one or two minutes a day soon adds up to a giant error. (A one-minute clock error translates into a navigation error of 28 kilometers at the equator, or 22 kilometers at the latitude of New York City.)

The orbit of the moon is extremely complicated, and the background of stars was not well mapped. Observing and predicting the orbit with enough precision for navigation required several theoretical breakthroughs, and a tremendous research program that began in earnest in 1675 and took two generations to bear fruit. The most important theoretical contribution was Newton's law of gravity. This was applied to the moon's orbit in a detailed analysis by Halley, which was refined by Mayer and Euler. In the following centuries, an army of scientific grunt workers refined the methods and made ever more exact observations to perfect the method. The data was worked out in advance and packaged in tables, which were published in the thick British Naval Almanac years in advance for the benefit of navigators. In 1922 it was estimated that more human computation had been expended determining the position of the moon than in any other problem of astronomy or physics.[9]

This was Big Science. It cost gobs of tax money, it cranked out big, thick tables of numbers, and it kept cranking them out 90 years after they were no longer needed, by most accounts.[10] How well did lunar navigation work? In the hands of Maskelyne himself, the astronomer royal who championed the method for 40 years, it took seven observations and four hours of computation.[11] Maskelyne understood the underlying principles of the method. An ordinary navigator would follow instructions blindly, in cookbook procedures, which makes it more likely he would blunder without noticing it. In the years that followed, the lunar method was refined and refined again, with more steps prepackaged in tables. The computation time was cut in half, and eventually halved again, to about an hour for a skilled person. But in the meanwhile, chronometers were getting better and better. By the end of the 18th century, comparison tests showed the chronometer method was an order of magnitude more precise, primarily because it was so much easier. It was, as we say nowadays, user-friendly and automated.

The astronomers were convinced the lunar method was the answer. They became so convinced, they fought the chronometer. They attacked Harrison and the other clock makers as them "mere mechanicks." Maskelyne was the head of the Board of Longitude. He and other members of the establishment hoped to secure the £20,000 prize for someone in their camp. They wanted the academic fame and credit, plus the money. This was a conflict of interest as bad as the DoE's role in cold fusion. The astronomers used every dirty trick in the book. They ignored the data, moved the goalposts, changed the rules, and rigged the tests. Huizenga and the others who have been trying to squash cold fusion could learn a few lessons from them.

The astronomer clique dismissed the results of the first sea trials as flukes that could never be repeated, and then they worked behind the scenes to prevent another sea trial. In the 1762 tests, after more than two rough months at sea, H-4 lost only 5 to 9 seconds.[12] Defying logic, science and common sense, the Board of Longitude airily dismissed this performance, declaring: "tho' not yet found to be of such great use for discovering the longitude . . . [the chronometer] is nevertheless an invention of considerable utility to the public." This infuriating remark reminds me of statements like: "cold fusion might just be an interesting form of chemical energy storage," which are repeated by the opposition *ad nauseam*.

Maskelyne's favorite trick was to move the goal posts and change the rules every time Harrison got close to winning the prize. Harrison's son William tested H-4 in a sea trial to the Bahamas and back to England. When he returned, the Board of Longitude informed him that the test was invalid because he had not calibrated it in the Bahamas according to the moons of Jupiter. This requirement was ridiculous. They did not tell him about it until he got back, when it was too late. It took an expert astronomer to perform that test; William was not capable of it. Furthermore, the map coordinates of Port Royal, Jamaica were well established by 1762, and the local time could be measured precisely. The astronomers were demanding that William become an instant expert at their game as well as his own. They wanted him to prove his technology using their favorite he-man technique, the way the hot fusion scientists demand neutron studies to prove that cold fusion produces heat and transmutations. You do not need neutrons; calorimetry and mass spectrometry prove the point, just as measuring high noon in the Bahamas will confirm that your clock is still set to Greenwich time.

In his official capacity as tester, Maskelyne rigged such a blatantly crooked test it might even embarrass the anti-cold fusion scientists at the MIT Plasma Fusion Center in 1989. He left the clock in a window seat, in direct sunlight, while he recorded the temperature in the

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shade on the other side of the room. King George III, who was a talented amateur horologist and scientist, intervened and had the H-5 clock verified in his own laboratory.

As chronometers become cheaper and more widespread, the astronomer clique continued moving the goalposts to prevent more official rewards and government approval. The original law left the rules up to the discretion of the Board of Longitude. In 1773 the astronomers pushed through an Act establishing an explicit, strict set of rules. Entries had to be submitted in duplicate, undergo a year of trials at Greenwich, two sea voyages around Great Britain, and then a year of other voyages to any other destinations the Board might dream up. Sobel writes:[13]

> Maskelyne was heard chortling that the act "had given the mechanics a bone to pick that would crack their teeth."
>
> The words proved prophetic, for the prize money was never claimed.

By this time the horologists were beginning to make money selling chronometers to customers. Presumably they were no longer interested in playing a silly academic game. Cold fusion scientists should have learned this lesson years ago. When the opposition can set the rules and change them anytime, and the opposition referees the game, you cannot win.

In the end, the customers decided the issue. Ship captains and Navy officers took the initiative and began buying chronometers. They even bought good conventional watches. They ignored the academic battles and used existing technology effectively. The academics argued that there was no solution to the fact that temperature and humidity changes played hob with precision. The sailors kept the watches in their pockets: not a perfect solution, but it helped. At first, before chronometers became reliable for months without resetting, experienced navigators would check them every few weeks with the lunar method. They would calibrate again when they reached port at a known location. To assist the calibration, it soon became customary in harbors and ports to set off a time signal at high noon or 1:00 p.m., by raising a flag or firing a cannon. The most famous time signal is still performed every day at Greenwich Observatory, as it has been since 1833. By that time the old generation of astronomers had died out. Opposition to chronometers ended after a 50-year rearguard battle by the establishment to prevent this life-saving technology from reaching the Navy and merchant marine. Let us hope the opposition to cold fusion does not last as long.

Plenty of Blame to Go Around

The historians blame the astronomers for the delay, but Harrison himself does not escape criticism. He is usually portrayed as a lone hero struggling against the establishment, but from the beginning he had powerful establishment friends, including members of the Board. Not all astronomers were against him. Halley was one of his biggest supporters. Halley was the astronomer royal when Harrison built H-1. The Board awarded him substantial grants to sustain the work on each of the prototypes. He became a member of the Royal Society after building H-1, he was awarded the Copley Gold Medal in 1749 while working on H-3, and he was even invited to become a Fellow. He was not an outsider at every stage in his life. Cold fusion is sometimes portrayed as "garage science" invented by and sustained by people outside the establishment. This is absurd. Martin Fleischmann is a Fellow of the Royal Society. Most important cold fusion experiments have been performed in places like Los Alamos and SRI, and most funding comes from the Japanese government.

Harrison's personality defects caused much of the controversy. He was obstinate, argumentative, secretive, slow moving, and an obsessive perfectionist beyond any technically justifiable level. He had an effective chronometer in 1835. He tested it at sea, and it worked beautifully. The Royal Society praised it lavishly, giving him "a hero's welcome." The Board thought highly of the machine and gave him the first of many substantial grants (£500, equivalent to $300,000 today). He should have asked the Board for the reward, or a large chunk of it, in return for giving the clock to the world. Or he should have submitted a plan to hire a 5-man research and development team, and asked for a larger grant. The endorsement of the Royal Society surely carried enough weight to finance a project on that scale. He could have built new clocks in a few years. Instead, he revealed no substantial information, and he insisted on working by himself for 24 more years! The H-1 clock was displayed, but he kept the construction techniques and theory of operation secret. Decades later he was still attacking his friends for revealing technical details about H-1. People suffering from the inventor's disease often want to do all the work themselves, because they do not trust anyone, and they think nobody else can meet their impossibly high standards. This is also characteristic of scientific geniuses like George Washington Carver. Ignoring other people's work is another symptom. Fortunately, Harrison was jarred out of his complacency. In 1753, he commissioned Jefferys to make a pocket watch according to his specifications for his own personal use. It worked so well that it forced him to rethink the problem from scratch. Essentially, he decided to make an overgrown pocket watch, giving it some of the features of H-1, H-2 and H-3. He produced H-4, a radically different design weighing only 3 pounds, compared to the 60 to 86 pounds the three previous machines weighed.

Harrison said that the 20 years he devoted to H-3 was time well spent, because he learned a great deal that enabled him to build H-4. Perhaps that is so, but H-1 solved the problem, and John Harrison was not the only person in England capable of building good clocks. If he had claimed the prize and shared his knowledge in the 1730s, other master horologists would soon have learned to make effective chronometers, as they finally did in the 1770s. The Board ordered Harrison to publish a detailed description of H-4. His writing was incomprehensible but the book included schematics. Other books about the new technology circulated. Le Roy's book describing Harrison's clock was translated into English the year it was published.[14]

Sometimes it takes a lone genius to solve a problem. He publishes a working solution, and many near-geniuses rush to advance the work beyond the ability of the original discoverer. The Wright brothers were a classic example. Working single-handedly, they solved virtually all the problems of flight. They invented the wind tunnel, they compiled hundreds of pages of data, did the physics, and invented effective controls, wings, propellers, and other essentials. But they reached the limits of their abilities in the 1906 patent and made little progress after that. When the details of their work finally became widely known in 1908, scores of talented people rushed into the field, and they pushed the technology farther along in the next two years than the Wrights had brought it in the previous ten. People like Sopwith and Sikorsky may not have had the Wrights' spark of originality, but they quickly mastered the physics and learned to make far better aircraft than the Wrights ever did. The ideal pioneer is not the best person to bring a technology to fruition. Pioneers like Harrison are too exacting,

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too patient, too willing to spend years working on problems that should be taken care of in months.

During this 24-year saga, and during the battle over the prize money that followed, the Board had to twist Harrison's arm and force him to reveal aspects of the work. He was too old to produce more clocks, so he should have either patented the designs and sold them, or given them to the government in return for the prize. Instead he fought to have his cake and eat it too. I do not know if Harrison began his career acting like this, or whether the opposition gradually warped his personality, but there is no doubt that for most of his life he was suffering from a full-blown case of the inventor's disease, like so many cold fusion scientists.

No one can capture every nuance or probe every aspect of the story, especially in a short account like Sobel's. She cannot cover the details but she makes it clear that Harrison was partly to blame. She presents the story as a triumph over adversity, but with my experience dealing with the cold fusion scientists, I see it as a tragic delay brought about by a man who was his own worst enemy for decades. Sobel understands the point of view of Harrison's academic opponents, even his nemesis Maskelyne, who did have some legitimate complaints. The Board had a legal mandate from Parliament to find a "Practicable and Useful" method of finding longitude, and Harrison's clocks were anything but practical. They were extraordinary one-of-a-kind masterpieces. Only Harrison could build such clocks. Using them on a ship was roughly equivalent to navigating an airplane with a custom-designed Cray supercomputer. It is the sort of thing you might do in an experiment to determine the theoretical feasibility of a method. Even his H-4 clock cost too much to be practical. The Board paid another master horologist, Kendall, £500 to replicate it in a two-year project. (The Board gave this K-1 chronometer to the famed explorer Captain James Cook, for testing.) By any reasonable engineering standard, Har-rison did <u>not</u> solve the longitude problem any more than cold fusion scientists have solved the energy crisis. You do not see cold fusion powered cars on the road yet. When Harrison collected the prize money, there was only one ship at sea using his chronometer, and it was anyone's guess as to how long it would be before other chronometers could be manufactured. And there is no denying the fact that the lunar method was practical and available to anyone at a nominal cost. Over the next 120 years the lunar method was simplified and sped up. If Harrison had not come along it would have been improved sooner.

This is not to suggest that Harrison didn't deserve the prize money. In the end everyone, even the Board, acknowledged that he did. During the 28 years he worked on H-1 through H-4, Harrison did not ask for the prize money. Instead, he asked for – and got – research grants. After H-4 passed the sea tests, late in his life, he began demanding the prize, and arguing with the Board. By that time other horologists were making rapid progress toward building cost-effective chronometers, so the method he pioneered was becoming practical. The Board wanted Harrison to share his knowledge and promote this progress. Harrison wanted the prize money first. He received a partial payment of £1,500, he was offered £10,000 more for publishing the details of his work so that others could learn from him, and the final installment for making two copies of the watch. He was only able to make one copy, but the King intervened and he got the final payment anyway, at age 79, three years before he died. The negotiations and the government's ever-changing terms and conditions infuriated Harrison. On the other hand, Harrison upset the government and alienated everyone, including his friends and supporters. The government was offering him a much better deal than a patent. It would give him far more profit than anyone could have expected from a patent, even in 20 years, and the money would come when he was old and could not expect to work or live much longer. Chronometers were soon selling at £50 to £100 each. You would have to sell thousands to make £20,000 net profit. It was 20 or 30 years before total unit sales from all manufactures passed the thousands mark.

It seems Harrison lost faith with the government and did not trust that if he revealed the secret, he would be paid as promised. Harrison had every reason to mistrust his arch enemies the astronomers, but the Board did not consist of astronomers alone, and Harrison had many friends and admirers he could have called upon if the government had reneged. He <u>should</u> have trusted the government. It had paid him generous research grants for 24 years, and £1,500 in prize money for a technology still in the experimental stage. Finally, Lord Egmont, head of the Board, scolded him: "Sir . . . you are the strangest and most obstinate creature that I have ever met with, and, would you do what we want you to do, and which is in your power, I will give you my word to give you the money, if you will but do it!"[15] I wish I was in a position to say the same thing to the strange and obstinate cold fusion scientists!

The long delayed introduction of the chronometer, the paranoid secrecy, and the battle over the prize money were tragic fiascos, no matter how you look at it, no matter who was to blame. The lunar method should never have been considered a competitor with the chronometer. Both were vital in the early years, when most chronometers had to be calibrated every few weeks. The methods dovetailed together perfectly: they were complementary, not competitive. From the start, the astronomers and horologists should have cooperated, as they did after the hardliner astronomers died. I am haunted by the suspicion that the hot fusion and cold fusion people should be working together.

The Role of Government

This sad history raises questions about the proper role of government in encouraging technology. You could argue that the £20,000 reward retarded the technology as much as it encouraged it. The prize set up a false dichotomy. In people's minds one prize meant there must be one solution, instead of many solutions that work best together. As it turned out, the Board awarded many prizes to people in both camps over a period of 110 years. Government funding often produces this kind of artificial winner-take-all focus, the hot fusion program being a prime example. There is no technical justification for putting all of the energy eggs in one basket at this stage. It is done because in a government program, an individual or a committee makes a conscious decision to fund one project and not another. Such decisions should be left to the free market. The 18th century shipbuilders, captains and insurance companies might have had effective navigation instruments a generation earlier if they had started throwing money at the problem themselves instead of asking Parliament to allocate money for the "best" solution. Fortunately, the Board had the good sense to break the prize into smaller, partial awards. By the time the Board was officially disbanded in 1828, it had awarded over £100,000. The research grants and smaller awards the Board gave to Harrison, Euler and others were a wise investment of tax money, but the high stakes prize money focussed too much attention on the government's blue ribbon panel.

I believe that the British shipping industry and Navy were not oriented to capitalist, free market solutions. It was not part of their tradition. They were used to institutions like the East India Company, an authoritarian, government sanctioned cartel with absolute control over British trade

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with China and India. Full capitalistic competition and scientific shipbuilding did not come to the British merchant marine until the reforms of the 1850s.[16]

Government has played a major role in science and technology from the beginning of the industrial revolution up to the present day. In many cases, the benefits of government investment and intervention in the market have been indisputable. Land grant colleges and government sponsored projects like the transcontinental railroad were essential to 19th century nation building. Anyone who doubts the wisdom of the pure food and drug laws should spend an afternoon reading the advertisements in respectable turn-of-the-century magazines. Without FAA regulations people would not have the confidence to ride on airplanes. But other government initiatives have engendered controversy, opposition, and mixed results. There are many examples. In the 1850s the government was criticized for subsidizing ocean-going steamships in unfair competition with sailing ships;[17] today the government's role in the SEMATEC semiconductor R&D consortium is questioned.[18] There has never been significant government support for cold fusion in the U.S. or Europe, and I doubt there ever will be, unless cold fusion emerges as a full-fledged industry. Perhaps this is best. Government support is a two-edged sword.

Some Other Lessons

The story of the chronometer offers many other lessons to cold fusion:

• Technology cannot solve the problem unless it is marketed and promoted. It is never enough to invent something. Products do not sell themselves. According to Gould, 30 years after Harrison died, some American ships still sailed without chronometers or even sextants, relying on dead reckoning.[19] Chronometers would not have gone anywhere if ship captains and officers had not become interested in them, and if they had not found ways to use the imperfect technology of the late 18th century. In a sense, when Captain Cook wrote a rave review of the K-1 chronometer, he did as much for the technology as Harrison did.

• Secret solutions are useless. If he had not been pressured by the Board, Harrison would have taken his secrets to the grave. There is no telling how long it would have taken to rediscover them. The Chinese invented and reinvented clocks many times during their long history.[20] The designs were state secrets, so they might as well never have existed for all the good they did.

• You do not always get rich from inventing the perfect solution to a problem. After Harrison, British chronometer makers perfected their art so well they put themselves out of business.[21] With proper maintenance the instruments lasted for decades or even a century, being passed from one ship to another. By the early 1900s there was only one manufacturing firm left, which was enough to keep up with demand for new clocks and replacements.

• Anyone wishing to develop, promote, or make a fortune selling cold fusion should study history. There are lessons to be learned from the history of any technology, even inconsequential ones like the zipper.[22] Human nature does not change. The mindset, politics and machinations of the astronomers in 1770 resemble those of the hot fusion scientists today. We can anticipate the tactics of the opposition – read their minds, in effect – and learn how the horologists overcame similar tactics 180 years ago. Harrison's mistakes and his personality defects can be seen in most cold fusion scientists today. Great scientists often make great errors when their genius and self-confidence betray them. Their strengths become weaknesses. Edison wasted millions of dollars on magnetic iron ore separation techniques, in a tragically misguided venture. Santayana's chilling dictum says it all: "Those who cannot remember the past are condemned to repeat it."

Notes:

1. D. Sobel, *Longitude*, (Walker, 1995), p. 8 - 9.
2. *Microsoft® Encarta® 96 Encyclopedia*. (Microsoft Corporation, 1995).
3. D. Landes, *Revolution in Time*, (Har-vard University Press, 1983), p. 156.
4. Landes, p. 152.
5. M. Fleischmann, G. Larramona, S. Pons, H. Sugiura, G. Preparata, "Alfred Cohen and After: the Alpha-Beta-Gamma of the Pd-H System," presented at ICCF4.
6. E. Mallove, *Fire from Ice*, (John Wiley & Sons, 1991), p. 105.
7. Landes, p. 165
8. Landes, pp. 165,166.
9. Landes, p. 153, quoting Sir Frank Dyson, Astronomer Royal in 1922.
10. On the other hand, R. Scheen wrote that the Almanac "has proved its great value for the seafaring man using celestial navigation." R. Scheen, *The Lore of Ships*, (Holt, Rinehart and Winston, 1963), p. 224.
11. Landes, p. 155.
12. Accounts vary about the number of days at sea and the total seconds lost. Sobel puts it at 81 days, which puts the start on November 1. An account written by Britten in 1899 says the voyage was 61 days, starting Nov. 18. It is surprising how many discrepancies one finds about such basic facts. See: G. H. Baillie et al., *Britten's Old Clocks and Watches and their Makers*, 7th ed., (Bonanza Books, 1956).
13. Sobel, p. 149.
14. P. Le Roy, *A Succinct Account of the Attempts of Messrs. Harrison and Le Roy for Finding the Longitude at Sea, and of the Proofs Made of Their Works*, translated by a Fellow of the Royal Society (London: F. Newberry, 1768).
15. Sobel, p. 131.
16. A. Laing, *Clipper Ship Men*, (Duell, Sloan & Pearce, 1944), p. 173. The problems were widely recognized. Laing quotes the Encyclopedia Britannica 1840 edition: " . . . the mercantile navy of England is the least speedy and most unsafe that belongs to any civilized nation."
17. Laing, p. 268.
18. L. P. Randazzese, "Semiconductor Subsidies," *Scientific American*, June 1996.
19. Landes quotes Gould, p. 186.
20. Landes, chapter 1.
21. Landes, p. 186, describing the argument of A. C. Davies, "The Life and Death of a Scientific Instrument: The Marine Chronometer, 1770-1920," *Annals of Science* 35 (1978) pp. 509-525.
22. For a fascinating look at the history of the zipper, see: R. Friedel, *Zipper – An Exploration in Novelty*, (Norton, 1994).
23. R. Conot, *A Streak of Luck*, (Seaview Books, Simon and Schuster, 1979).

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pulse generator circuitry, for the LMD™ and the XS NRG™ Energy Conversion System has been obtained in the U.S.A. via the granting of three separate patents by the U.S.P.T.O. (United States Patent and Trademark Office) in 1995 and 1996. A fourth patent has also been issued in Great Britain, in 1996. Other applications are under national phase examination.

• Jointly with M.N. Correa, Architects, of Lisbon, Portugal, Dr. P. Correa and A. Correa are presently in process of patenting a modular, energy self-sufficient building system, that utilizes the XS NRG™ power generation system.

• Jointly with Dr. H. Aspden (Ph.D., C.Eng., previously European Director of IBM Patent Operations and Prof. of Electrical engineering at Southampton University), Dr. P. Correa and Ms. A. Correa are currently preparing a patent application for the design of the power plant and engine of an electric vehicle.

• Other work at Labofex in the past two years has focused on anomalous electrostatic effects, the analysis of open circuit functions and the experimental verification of the equivalence of magnetic and electric charges. This theoretical and experimental work has opened other vistas regarding different methods of energy conversion.

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COLD FUSION AND NEW ENERGY — AN ENVIRONMENTALIST'S PERSPECTIVE

by Nick Palmer, group coordinator and energy campaigner for Jersey (UK) Friends of the Earth

When I first saw cold fusion demonstrated on television, back in 1989, I was enthused with what the future could hold. Subsequently, it was apparently discredited and I thought I'd been fooled. Having rediscovered the topic on Compuserve last year, and followed it up, I am now happy to report that I had been fooled again! This time, it looks real because there is just too much reliable evidence piling up —when the walls of the old physics paradigm finally crumble, it will unleash a tidal wave of change throughout the world.

This article was hard to write because I found that there was an almost physical force that tried to make me put off doing it. Whilst my conscious mind is thrilled about the future that these devices may lead to, I have found that other parts of my awareness seem to resent the large amount of rethinking that the environmental movement will have to do to assimilate the changes in outlook that the new energy devices will necessitate.

In the environmental movement, we had our strategy all mapped out to achieve a sustainable and equitable world civilization based upon the efficient use of the minimum of renewable energy and a greatly decreased consumption of raw materials. This would have needed tough decisions and discipline, but, as the consequences of not doing so would have been eventually catastrophic, it was something that had to be done. A lot of people have invested a lot of time working out Green theories and strategy and one of the biggest aspects of this was how we would have to rely upon sustainable, renewable energy sources in the future. This would have had consequences for virtually every aspect of the developed nations' world and also for the third world too as they attempted to industrialize. Then along come new technologies, without any definite theoretical basis, that threaten or promise (depending on one's point of view) to completely alter all this. No wonder some are wary of commitment to them.

So, why is there this resistance? - simply, it is the classic psychological dilemma of the gambler on a losing streak. Having once started to lose, the only way one can regain the losses is to carry on gambling. Quitting the game means a definite loss, whereas further, and probably wilder, gambling hold out the slight prospect of the recapture of losses. Similarly, having talked to colleagues at American Friends of the Earth, Greenpeace, and UK Friends of the Earth, I must say that while they don't display the rabid scepticism that much of the scientific establishment is showing, their initial enthusiasm seems to be hard to translate into action—they all like the sound of it, but I sense a certain reluctance to train the big guns of the movement upon the topic. I think this is because accepting the reality of these devices means that a lot of the textbooks will have to be thrown away and, more significantly, those with expertise and careers in the area of future sustainable energy supply will find that much of their life's work is now redundant. This can be a frightening prospect, but the environmental movement has always been more open minded and fluid in its thinking than the mainstream, so I hope we will be able to make the change fairly smoothly. It must be much more daunting if one has made a career in "hot fusion" research to see one's research funds drying up and even more galling and humiliating to see what you can just about do with enormously expensive and powerful machinery being achieved almost at the garage inventor level — no wonder, like the gambler in the dilemma, mainstream "priest class" scientists will continue to cling onto a hope that they won't have to throw out their life's work.

An energy report commissioned

Friends of the Earth UK has commissioned a report into the energy sector as a whole, and our energy campaign group has asked the researcher to look into cold fusion et al. They have passed on a letter that I sent, plus various information on the new energy inventions, to him.

I also intend to take a motion to our UK Conference, in the Autumn, suggesting that we thoroughly investigate all the ramifications of these new energy sources, once we have satisfied ourselves of their reality and potential. Having done this, we should then heavily promote them as a solution to global warming and the general energy crisis that looms ahead. Of course, these devices mean the effective end of our old enemy, the nuclear power industry and so I think, on balance, that we will embrace this technology.

I anticipate that the environmental organizations will adopt different campaign priorities which take into account the fundamental change in energy supply options for the future that these devices will cause. There will be some aspects that may seem to act against current environmental campaigning; for example, if cars in the future are pollution-free, quiet, and don't contribute towards climate change, much of our current arguments will be dissipated. Of course there are many other perfectly good reasons why unlimited personal transport isn't good, environmentally speaking, and so our case won't be terminally weakened—it will enable us to focus more on certain aspects of our civilization that need addressing.

Barring hidden drawbacks, and given what could be a relatively small amount of additional technological and engineering development, these assorted new energy devices herald the effective end of the nuclear and fossil fueled industries and give us a quick fix for climate instability caused by human instigated global warming. Not so obviously, they should lead to the breaking of the grip on supply of energy by those favoured nations with resources of oil, coal or fissionable nuclear material. It is also likely that many large corporations will fade away as the supply of "point of use" energy that these devices herald will tend to enable nations, states, districts, and even individuals to become progressively more autonomous. There is much in environmental theory about the benefits of "small is beautiful" which boils down to the fact that the more human scale any nation, economy, industry, technology or whatever is, the more satisfying it is for the human spirit. Cold fusion and the other devices could free us from our top-heavy Mega-corporations, not with revolution or strict legislation, but just by their very nature. It is probable that what started out as fractions of a watt excess energy in the beakers of Pons and Fleischmann will lead to a very different type of civilization. It will be less possible for powerful nations or large corporations to "corner the market" or gain a strangle hold on supplies —their excess political and financial power will evaporate.

As if to temper all this wild enthusiasm about free energy, some have pointed out that even though such devices as solar cells supply "free" energy, they still cannot compete with conventional sources because the fuel cost is not the only economic factor. If we get unlimited energy from the new devices, it wouldn't be quite so world shaking if their capital cost and maintenance proved expensive by comparison with nuclear or fossil fueled power sources. As environmentalists, however, we would still be for them, almost regardless of cost, because of their obvious benefits in reducing or eliminating, in double quick time, pollution and —the big one — global warming. As it hap-pens, it looks as if they will not only supply abundant clean energy, but they will also prove to be cheap to buy and possibly free to run too — the solar-cell argument above, meant to subdue excess extrapolation, doesn't hold.

Freedom from the "grid" will lead to virtual independence of supply for individuals. The Third World will have access to the "energy slaves" that have kept us so comfortable in the West — energy is fun-

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damental to an acceptable quality of life. The remotest villages will no longer have to deforest for firewood; they will be able to purify water; they will have easy refrigeration — improved hygiene will lead to a falling off of disease and epidemics. The Third World won't need the fortune that they haven't yet got to catch up with us by buying expensive western technology; having the latest technology to achieve any goal becomes much less relevant, because with unlimited energy it won't matter so much if any process is relatively energy inefficient. The developing Third World is a crucial aspect of any environmental strategy. If the Third world industrializes to the same degree that we in the developed world have, a simple calculation shows that total demand for resources, by the middle of the next century, will rise to around ten times current levels which is undoubtedly unsustainable, but the Third World must develop to stabilize world population and so environmentalists were rather caught on the horns of a dilemma. What needed to be done to re-jig the consumer society was so huge that I frankly doubted that we could have done it in time. New Energy will give us that time.

A Dutch study concluded that one's fair share of air travel in a fully sustainable world was just one transatlantic flight in a lifetime. How would we have sold this notion to travel consumers, some of whom take two to three long-haul holidays every year? It would have been difficult, to say the least. If fuel weight and capacity is no longer a consideration, planes and boats etc. can be bigger. Range will be indefinite. We may very well end up with our own personal air transport, in the longer term, which would lead to a withering away of the roads network. Magnetic levitation trains may become much more viable.

If we have air transport "fuelled" by clean energy, the future of tourism will not be blighted by the application of current environmental theory, but this doesn't mean, of course, that one can neglect the other environmentally destructive effects of mass tourism because these will become even more important. Again, we will be able to focus on such issues more.

Design of many machines and consumer products could change because there will no longer need to be such a trade-off to achieve such aims as a good power to weight ratio to achieve fuel efficiency. The "embodied energy" in a product, currently a significant aspect of manufacturing costs, would not matter too much. Things could be engineered to last a lot longer, so, for example, cars could be made with heavier grade steel (much more resistant to corrosion) and notwithstanding crash protection "crumple zones," they could be made much more robust so they didn't fall apart after ten years or so.

Some recycling or reuse is criticised on the grounds that the amount of energy saved by the process is comparable with that needed to manufacture the item or substance from virgin material in the first place — a similar argument also applies to the amount of pollution created or avoided. It is just not viable to recycle some types of material because the energy balance is actually negative - it would take more energy for the recycling process than would be saved. Calculations such as these are called Life Cycle Analyses (L.C.A's) and they are a rather powerful tool that some governments and corporations are using against our argument that we should change our profligate ways. Cold fusion and the other new energy devices will heavily alter the energy dynamics in favor of recycling and reuse as transport/reprocessing energy will no longer need to be considered in L.C.A.'s. The recovery of material resources will become much easier with abundant clean energy, and once a nation has acquired material resources, it will be able to reuse and recycle them much longer and, hopefully, indefinitely. This should increase general sustainable wealth.

A future developed world, with few, if any, areas subject to resource starvation, would tend to have a stable population, both numerically and psychologically. Most of the traditional causes of wars would have evaporated and any future conflicts may just come down to petty squabbles about territory.

Rapid development and a Golden Age

Once affordable devices are being manufactured, New Energy will be embraced by the people at a rate that will astonish the world; whether the existing energy supply corporations help or hinder the process, it will happen regardless. The first reaction of some to news of these developments is to assert that the oil companies will suppress them but, in this age of the Internet, I don't see this as possible any more — the genie is out of the bottle and we will have to ride any economic, institutional or social disruption that is coming our way. We can only hope that it will not be too dramatic, because the long-term gains, from this perspective look to be so far reaching that we may indeed be heading for a Golden Age of political stability, universal prosperity and environmental friendliness; this will surely be worth a period of uncertainty.

Our most urgent and powerful argument for radical change of society — the threat of climate change — looks like it has been diminished to non-significance. Society will probably change radically anyway. From all the thinking I have done on the subject, I believe that the overall effect of this will be a greener, more decentralized, civilization. Economies will be much more equitable because, once they have obtained raw materials, they will be able to keep on reusing, and then recycling, them almost indefinitely. The new energy sources will allow us to continue resetting the entropic clock that makes some sustainable practices rather impractical today. Those nations that are resource-rich will still have an initial advantage, but as time goes on this will tend to equalize towards the median —what will define the success, or otherwise, of nations in the future will be the industry, the talent, and the desires of the people. Whilst the future playing field will not be boringly level, it will not have the extreme peaks and troughs that cause excess, on the one hand, and such misery on the other.

It is quite clear that we have to achieve much greater recycling and reuse rates than we currently do — new energy will be just what is needed for this, but unfortunately there is always the possibility that access to abundant energy will lead to an increase in consumption over and above what is already forecast — this could be disastrous and so the environmental movement will still have much work to do here.

There is the physical and logical aspect of being Green which suggests that environmental problems can be solved by controlling use of energy, pollution and resources; there is also the spiritual dimension of being Green. We get a lot of the strength of our support from the fact that many people are dissatisfied with our profligate lifestyles and the basic values of the people and societies that espouse such values; it is debatable whether, chicken and egg fashion, a love of shallow, wasteful materialism is a consequence of something lacking in the modern Western way of life or whether it is the cause of the dissatisfaction that many feel. With access to abundant, virtually free, energy it would seem that people may be tempted to treat energy and the things it will bring us, as trivial and not to be conserved, rather as those people who pay a flat rate for their water supply tend to use more than those who have their supply metered. It looks as if the environmental movement can now concentrate on conserving and preserving our resources by encouraging people to treat them with respect - our task has been made simpler and less daunting because

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Do it—please!

Write a letter about cold fusion and new energy to your Congressman, Senator, President, favorite Presidential Candidate, or Prime Minister.

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Book Review and Comment...

The 7th and Last Edition: THE ENERGY MACHINE OF JOSEPH NEWMAN

Synopsis and Commentary by Mike Carrell

Synopsis

The 7th and Last Edition: THE ENERGY MACHINE OF JOSEPH NEWMAN is a testament, inscribed on 471 glossy pages and bound in white with gold lettering. It includes his conception of the fundamental structure of the universe, the over-unity electromagnetic machines he built, and his battle with the US Patent Office for recognition. Newman's flow of thought is based on analogies, mechanical models, and experimental observations. Throughout his book, Newman entreats his readers to set aside preconceptions and to 'master' his teachings.

In Chapter 1, Newman begins with Maxwell, noting that Maxwell based his equations on mechanical models, that "The energy in electromagnetic phenomena is mechanical energy (Maxwell)". In Chapter 2, Newman proceeds to the basic demonstration of the generation of an electric current by moving a wire through a magnetic field. The conventions for the direction of motion, the direction of the magnetic field, and the direction of the current are expressed by the familiar right-hand rule. In 1965, he realized that the interactions of the right-hand rule also apply to a spinning gyroscope and made the intuitive leap that the interactions of conductors and magnetic fields could be mechanically modeled if magnetic fields consisted of elemental spinning particles moving with the velocity of light, which Newman calls 'gyroscopic mechanical action.'

He further notes, "The energy in a magnetic field must be moving in a direction at the speed of light and must also have a gyroscopic spin at the speed of light: *here-in lies the mechanical essence of $E=MC^2$*" (Italics in original). Detailed drawings prepared by Evan R. Soulé show how the flow of these elemental gyroscopic particles can provide a mechanical, kinetic model to predict the attraction and repulsion of magnets, which is detailed in Chapter 3. These particles originate in the atoms of the magnet and return to them. He goes on to state, "I believe it is imperative to reiterate that the energy in any magnetic field is the energy which composes the elements of the atom and is literally Einstein's Equation of $E=MC^2$. *Such energy in the form of gyroscopic particles is the basic building block of all matter and provides the basis for the conceptual interface between energy and matter.* ....The prior teachings indicate that copper is non-magnetic and that the resulting magnetic field associated with current flow in copper is the result of the current. Those teachings are totally wrong. Copper is extremely magnetic! It is so magnetic that it deceives the observer...." (Emphasis in original).

Chapter 4 shows how these conclusions led to the characteristic construction of the Newman Energy Machines, which involve large air-core coils, some weighing hundreds of pounds. The function of the applied voltage is to align the gyroscopic particles in the mass of copper, thus creating a strong magnetic field, even though little current flows because of the length (and resistance) of the winding.

In an early model, 4200 lbs of 5 gauge wire is used to form a coil 4 ft. diameter and 3 ft. high. Within the coil, a cluster of six bar magnets, four feet long and weighing 600 lbs., rotate on a pivot so that the axis of rotation is at right angles to the axis of the coil. In videotapes of this machine, the rotation of the magnet cluster is started by hand, and thereafter rotates on its own. The energy machine is excited by a large number of small batteries connected in series to develop a few hundred volts.

1986 Photo of Joe Newman with one of his Energy Machines connected to a water pump.
(by Susan Leavines, Courtesy Evan Soulé)

Chapters 5 & 6 include notarized reports by Dr. Roger Hastings, a Principal Physicist with Sperry Univac. Hastings has made systematic tests of Newman's machines and prepared papers interpreting Newman's ideas for the scientific community. He has also testified on Newman's behalf to Congress. (In all these matters, Hastings was in no way representing Sperry Univac.)

In one test, eight fresh 1.5 v batteries were connected to a motor driving a small oil pump, which operated for 6 min., discharging the batteries to 60% of their original value. This established a measure of the energy capacity of the batteries. The same pump was connected to a Newman motor with a 90 lb. rotor, and run at the same speed, nominally consuming the same power. Eight fresh batteries of the same specification were connected to the Newman motor and were drained to 60% of the starting voltage in seven hours. There were additional tests of static torque and battery lifetime.

A smaller, portable unit was built by Newman for demonstrations. In this case, the exciting coil sits beside the rotor, a 14 lb magnet, attached to a special commutator. Both rotate on a shaft at right angles to the cylindrical axis of the magnet. In a conventional DC motor, the commutator switches the direction of current flow through the windings, and the polarity of the electromagnet, as the rotor turns. In the case of the Newman machine, with two poles on the permanent magnet rotor, the polarity is switched twice per revolution. In addition, the commutator a) connects the batteries to the coil, b) disconnects the coil and batteries, and c) shorts the coil multiple times during each half-rotation of the magnet.

In an analysis by Hastings, an oscillogram shows strong current, over an ampere, flowing in a series of bursts while the coil is 'disconnected' and the magnetic field is collapsing. This current is observed

Joe Newman with Newman motor-powered automobile used in 1987 test in Atlanta Superdome
(by Susan Leavines, Courtesy Evan Soulé)

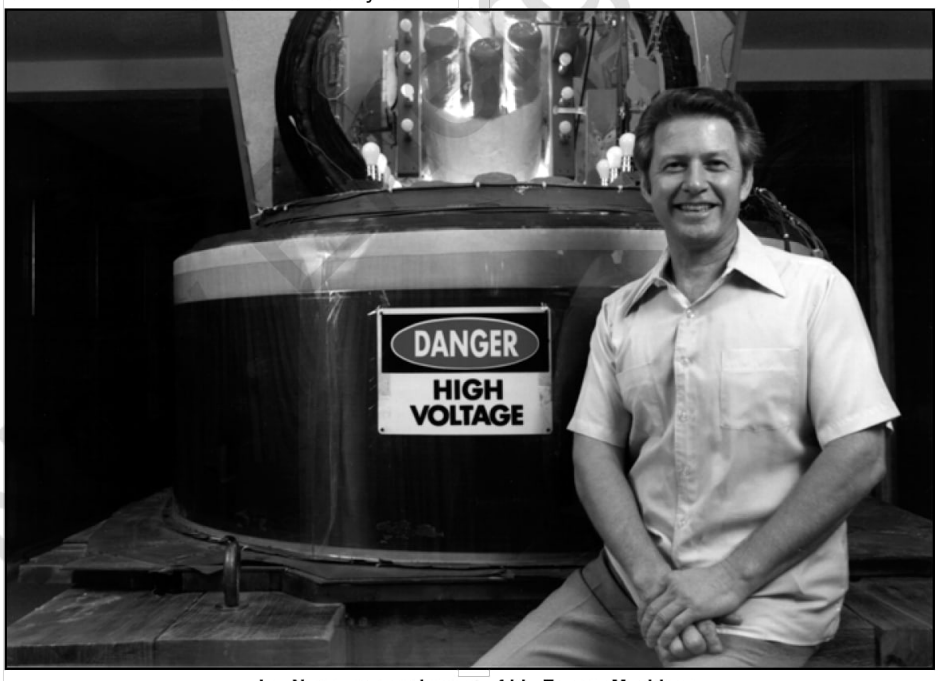
both in the 'coil' side of the commutator and the 'battery' side of the commutator. Since the inductance of the coil is estimated at 16000 henries, large voltages are generated on disconnection (a) as the magnetic field starts to collapse, resulting in arcing. Since an arc is highly conductive, the 'disconnection' is not complete. The coil, consisting of about 145 lb of 30 gauge wire, has a measured resistance of 50 Kohms.

More importantly, the oscillogram shows the presence of significant power and energy, not supplied by the battery, and confirmed by secondary thermal measurements made by Hastings. A 500 ohm resistor in series with the battery, placed in a calorimeter, showed a temperature rise equivalent to 14 ma, yet a standard dc ammeter indicated a current of 1.2 ma with the energy machine running, and 6 ma with the rotor stalled. The battery was a stack of 9-volt transistor batteries in series, producing 304 volts. A 14 ma drain on a sample battery produced a voltage drop of 2% per hour. In a four-hour test, a drop of 24 volts for the whole stack would be expected, but no drop was observed. The same batteries were used for long demonstrations over a period of months.

Hasting's notarized reports on both devices show substantially more power and energy out than that supplied by the batteries. In some demonstrations, substantially spent batteries are connected to the machine, which then partially recharges the batteries while doing mechanical work.

Chapter 7 consists of a list of 30 individuals with technical credentials (ranging from Ph.D. to technician) who have made affidavits endorsing the Newman Energy Machine. In addition William Schuyler, Jr., an expert nominated by the US Patent Office, "stated that the 'facts were overwhelming' that my device worked and that there was 'no contradictory evidence'." There follow several newspaper clippings reporting a demonstration of a car powered by a Newman motor powered by a stack of small transistor batteries. There are also some wiring diagrams and oscilligrams.

Chapter 8 consists of "Analogies Useful in Understanding the Technical System" using detailed illustrations and analogies to hydraulic systems.



Joe Newman near largest of his Energy Machines
(Photo by Susan Leavines, Courtesy Evan Soulé)

Chapter 9 illustrates the special action of Newman's commutator, which performs sequential energizing, open circuiting, and shorting of the magnet coil. He notes that "The 'timing effect' I have described is very critical." There are oscillograms of current waveforms.

In Chapter 10 he moves on to discuss quantum mechanics, noting that "…the essence of Magnetism, Electricity, Gravity, Inertia, Planetary Motion, and a New Source of Energy and Matter are all mechanically explained by the nature of a 'gyroscopic, action-type particle' " In Chapter 11 he discusses light and in Chapter 12 "Useful 'Work, Force and Power' Equations" in which he defines Obvious work, force, and power on the macroscopic level, and Unobvious work, force, and power on the molecular to subatomic levels.

Chapter 13 contains a 'Static Embodiment' conceptual design. Chapter 15 shows a Gas Embodiment, another conceptual design.

Chapter 16 embraces gravity; Chapter 17 extends to inertia; and Chapter 18 explains heat and the three laws of thermodynamics.

In Chapter 19, Newman lays out his work on astronomy, dating from 1976, in which he reviews evidence for electromagnetism as a major influence in the structure of weather systems, stars, planetary systems, and the galaxy. Supportive correspondence with Robert E. Smith of NASA Space Sciences Laboratory is included.

Chapter 20 consists of 84 pages of letters to US Presidents and other officials concerning the Energy Machine and Newman's conceptions of various fields of science. Included are a number of testimonials from local businessmen endorsing Newman's honesty and character. Three pages are devoted to a list of 56 universities to whom Newman sent a 25-page 'Scientific Document' in 1967.

Chapter 21 is an essay on proper teaching, in which he emphasizes the loving support of children and encouragement of independent thought. Chapter 22, a proof of God's existence, and Chapter 23 an essay on "The Merger Between Mechanization and Economics."

Chapters 24 and 25 document Newman's battle with the US Patent Office and the Judicial system, which is elaborated at length in the Appendix.

The Appendix, which comprises about half the book, contains more documents and explanations of various points of Newman's scientific concepts and updates of events and demonstrations.

Notable among the demonstrations was a 1800 lb car at the Atlanta Superdome in 1987. The car was driven by a Newman motor with a 200 lb coil and 200 lb magnet and powered by a stack of 1.5-volt cells of the type normally packaged as 9-volt transistor radio batteries. The cells were specially packaged by Ray-O-Vac for Newman. The same battery packs, without change or external charging, powered the car at a brisk walking pace for 10 hours before Atlanta, 20 hours at Atlanta, and another 45 minutes afterward, for a total of nearly 31 hours. Ray-O-Vac's data indicated that the batteries would be totally discharged in 25 hours with a 20 milliampere drain.

Included in the Appendix is a list of 173 "technical organizations / universities / libraries who have purchased published copies…" of Newman's book. An additional comment: "Both NASA and the National Science Foundation (NSF) have been eminently aware of Joseph Newman's work since the late 1960's and throughout the 1970s."

At the end of the Appendix there is a sketch of a compact embodiment of a Newman motor as a kind of gift to humanity. While there is not a lot of detail, the suggestion is that a reader who has absorbed and understood the prior work could build a working model.

Commentary

Newman's work and his Energy Machine have been a focus of discussion and controversy for many years. Many investigators have proposed, some patented and a few built electromagnetic devices for which over-unity, or 'free-energy ' claims have been made. A variety of models and demonstrations have been made, photographed and videotaped. Newman is possibly the most forceful of this group, who has shown determination and persistence in the face of opposition by the US Patent Office and a damaging report by the National Bureau of Standards.

Newman regards his fundamental contribution to be a universal field theory, based on elementary spinning particles, from which the customary particles and forces can be derived. The Energy Machines are conceived as demonstrations of the underlying theory, rather than useful devices in their own right. However, later models of the Energy Machine optimized as motors have been demonstrated sawing wood and other workaday tasks with little or no measurable power input.

Newman is one of many who have proposed theories of elementary entities from which the zoo of known particles can be derived. Some of these, dating back to the late 1800's, are based on vortices, which obey many of the same rules that Newman found for his 'gyroscopic particles'. Newman is bold in his extrapolation of his concept through fundamental physical phenomena to the cosmic level.

In a sense, we are all self-educated, though customarily with the guidance and certification of established teachers. Newman studied on his own, reading widely, and forming his own concepts. His formulations present difficulties to the larger scientific community, for there are many disagreements with measurements and concepts which have wide working acceptance in physics and engineering. Dr. Hastings has helped in supplemental calculations and interpretations of Newman's theories in conventional language; his notes in turn contain omissions and errors which have been the subject of discussions on some Internet forums.

Many of Newman's demonstrations use a stack of small batteries to develop the hundreds or thousands of volts used to excite the large coils. The endurance of these batteries in extended tests is given as direct, simple evidence of the unusual properties of the Energy Machines which run and do work well beyond the expected lifetime of the batteries.

Demonstrations, by their inherent nature, selectively expose and conceal information. Stage illusionists are the primary example, and some have made a career of duplicating the feats of people claiming paranormal abilities. When faced with a demonstration purporting to show unprecedented performance, a scientific observer must first be assured that the stated performance is not a mistake of measurement or interpretation, even though a gross, macroscopic effect is manifested. This is particularly true of suspected 'perpetual motion' machines, for there have been many extremely dramatic, clever and subtle demonstrations that were eventually proven fraudulent. Unfortunately Newman's machines are viewed by the US Patent Office as being in the 'perpetual motion' category.

The Newman Energy Machines, while simple in appearance, present great difficulties in measurement and analysis in conventional terms. The batteries used to energize the machines are themselves complex systems whose behavior is not at all simple in detail. The Energy Machines, in turn, develop high voltages, electrical oscillations, current surges, energize the batteries and perform work. Measurement of only one aspect of the energy manifestations can lead to wrong conclusions, as in the NBS tests.

The US Patent Office viewed Newman's Energy Machine as a ' perpetual motion machine'; summarily rejected his application, disallowed his theoretical explanations, and began an adversarial process which has continued to this day. In this, Newman has lots of company, for there are reportedly several hundred Cold Fusion patent applications which have been refused on similar grounds, with the notable exception of the Patterson and Kawai patents. The flow of events from Newman's viewpoint is amply documented in his book.

An important episode in the story is the evaluation of a Newman machine by the National Bureau of Standards. There was a breakdown in communication about the testing protocols to be used, with the result that NBS found no evidence of over-unity operation. Dr. Hastings later testified before Congress that the NBS procedures were grossly incorrect. Explicitly, NBS grounded the machine, draining RF energy (apparently to facilitate the use of certain measuring instruments) and made no attempt to measure the mechanical power output of the Energy Machine. The rest of this still-unfolding story is beyond the scope of this commentary.

The book contains several notes by Hastings, and others are available from Evan Soulé, Newman's information officer. While these are helpful, there is a lack of data and experimental evidence to meet some of the objections raised to various demonstrations available on videotape or in Newman's book. The response of Soulé to much of the criticism is to direct the critic to a careful study of Newman's book until one becomes comfortable with the concepts presented.

Newman has been visited by many people with technical qualifications who came as skeptics and left with a conviction that his machines manifest unusual characteristics. There has been extensive testing, using standard electronic instruments. Unfortunately, documentation of these tests is not readily available and the outside observer is left with a tantalizing patchwork of notes and claims which elude independent analysis. Ralph Hartwell has extensive contact with Newman and has made his own tests and observations of the Energy Machines. Stefan Hartmann has built Newman machines for his own independent study. Over the years, there has been a continuing evolution of Newman machines, with the emphasis shifting toward high-efficiency motor configurations.

There are interesting parallels between Newman's experience and that of Pons and Fleischmann. The opening years of the Cold Fusion saga are well documented in Dr. Mallove's book *Fire from Ice*, with further details of institutional obstruction and disinformation yet to be published. A

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1996 *Review of the "Cold Fusion" Effect* by Dr. Edmund Storms summarizes more than 190 studies from around the world reporting various aspects of the "Cold Fusion" phenomena, including transmutations, the Griggs machine, and of course the Patterson Power Cell. Before the series of Patterson/CETI demonstrations in 1995, the CF experiments were largely small scale and exploratory. In 1995, CETI staged a series of demonstrations of over-unity power and energy yields at technical conferences, climaxed by a short 1300 watt run at PowerGen 95 in Anaheim.

Before the CETI demonstrations, there was constant quibbling about the details of calorimitry, the validity of various instruments and procedures, and various theories to account for the experimental results, all in an effort to avoid the conclusion that a fundamentally new energy-yielding process was at work. This is proper and good science until it becomes denial in the face of evidence which has far-reaching institutional and economic consequences. The CETI/Anaheim demonstration was faithfully reported by Jed Rothwell and a few others, but a lack of some details left some vocal critics unsatisfied. Ongoing tests by Dr. Miley at the University of Illinois and Dr. Bowles at the University of Missouri have clearly replicated over-unity performance of the Patterson Power Cell and can be expected to yield a definitive study of the associated phenomena.

Taken alone, the CETI/Anaheim demonstration would raise as many questions as Newman's numerous demonstrations of his Energy Machine. Newman's demonstration of a car at the Atlanta Superdome was a similar landmark event. The CETI demonstrations exist in a context of closely related research. Newman's demonstrations also have a supporting context, including the affidavits of visitors and the Special Master appointed by the US Patent Office to examine the Energy Machine.

The larger context is the dozens of inventors who have proposed over-unity or free-energy devices. A number have been patented. Several have been built and demonstrated to witnesses without noticeable impact on the scientific or industrial community. A sampling of this world is contained in *The Free Energy Handbook*, compiled by David Hatcher Childress, several Internet home pages*, newsgroups and lists. Newman is perhaps the most determined and vocal member of this community. The emergence of the Takahashi and Kawai devices from Japan, apparently the result of twenty year's well-funded work, suggests a whole new context for Newman's work. Kawai has been granted a US patent for his motor. The patent contains performance measurements clearly showing 318% efficiency. Newman, who has been rebuffed by the US patent office, plans to sue Kawai and the United States Government.

While Newman denies that his machine is a 'perpetual motion' machine and claims that some of the mass of the copper coil is converted to energy, in the ratio expressed by the Einstein equation, the only evidence he presents is the performance of his Energy Machines and his supporting theory. Other inventors of 'magnetic' over-unity machines have invoked ' vacuum energy' or 'ZPF ' as the ultimate energy source. Newman and others are not to be faulted for a failure to show a known energy source -- for this is the crux of the whole matter, including the CF and cavitation devices.

A paper by T.E. Bearden, *The Master Principle of EM Overunity and the Japanese Overunity Engines*, published in the November 1995 - February 1996 issue of IE, proposes a theoretical context for the whole cluster of magnetic machines, including Newman's. Bearden's paper addresses fundamental concepts of modern physics. He suggests that tapping the vacuum energy is not some hidden, exotic process, but as obvious as a flashlight when correctly understood. Every electric dipole and magnetic dipole are already free energy sources.

Bearden is thus curiously close to Newman's conception of a magnet as manifesting a flow of elementary spinning particles. Newman has company in this respect, too, for there have been numerous proposals - beginning in the late 19th century - to explain physical effects by vortices in an aether-like substrate. The well-known physicist David Bohm noted that the property of spin attributed to electrons is more exactly described as a helical motion along a path. Physicist Robert Matherne found a passage in one of Nobel Laureate Richard Feynman's lectures, regarding basic particles and fields, "….the field itself has such familiar properties as energy content and momentum, just as particles can have…" Mathern compares this to Newman's statement "…the magnetic field consists of GYROSCOPIC TYPE PARTICLES which are the mechanical essence of $E=MC^2$ and represent an orderly flow of energy."

A paper by Osamu Ide, published in *J. Appl. Phys.*, Vol 77, No.11, June 1995, is also context for the Newman Energy Machine. The paper was summarized in *IE#*3, July-Aug.1995, p.33. Ide reports on an experiment with a simple LRC circuit in which the inductance comprises iron core windings, opposed physically and magnetically, between which a moveable magnetic core can pass. A capacitor is charged then discharged into the inductance under the control of SCR's timed to operate with the position of the passing magnetic core. Ide shows that, if the windings of the inductance are connected so that the fields oppose, then anomalous energy is returned to the capacitor during the operation of the experimental apparatus. The anomalous energy does not appear if the magnetic cores are connected so that the fields attract. The Ide paper is a simple report of a curious experiement, but Ide's association with the Clean Energy Laboratory, Natural Group Corporation, Shinagawa, Japan, is as interesting as Kawai's association with the Sumimoto Group, a major Japanese corporation.

Newman extended his theory to astronomy in Chapter 19 of his book, where he discusses sunspots, the orientation of the planetary axes of rotation, and a configuration of the galaxy as dominated by electromagnetic effects mediated by the gyroscopic particles. Honnes Alfven, a Nobel Laureate and an expert on plasma physics, arrived at very similar conclusions. Eric Lerner's book *The Big Bang Never Happened* is a very readable account of Alfven's work, which began before Newman's. Alfven proceeded from laboratory experiments in high density plasmas which showed structures resembling galaxies, and using scaling laws showed consistency between laboratory experiments and astronomical observations. He also encountered a refusal be a prominent mathematician to look at a physical experiment demonstrating an exception to the prevailing theoretical model.

Newman proceeded from mechanical models and analogies to develop his concepts, which have not found formal mathematical expression. Alfven worked from laboratory experiment within the mathematical framework of fundamental physics and his work has been essential in the design of plasma fusion reactors. Ide also provides a precisely described, limited, but provocative experiment.

In a conversation with Newman, he asked me to convey that the over-riding motive for his struggle, his "sacrifice," is to provide an example to students everywhere to continue to adhere to the truth of their own observations and convictions, even when these are at odds with prevailing opinion (my paraphrase). According to Evan Soulé, Newman is currently negotiating arrangements for full production of his Energy Machines.

This story is by no means complete or finished. The issues of priority are too complex for discussion here. Just as there

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is supporting context for the 'cold fusion' phenomena, so there is supporting context for the over-unity magnetic devices, including the Energy Machine of Joseph Newman. It is quite possible that none of the theories now promoted is wholly correct, for the cavitation machines have not been explained.

Acknowledgments
The author wishes to thank Joseph Newman, Evan Soulé, Stephan Hartmann, and Ralph Hartwell, for extended conversations and dialogue in the preparation of this review. Bob Shannon and other participants of freenrg-l are also thanked for a spirited discussion which was reviewed as well. The contents of this article remain the responsibility of the author.

•http://home.earthlink.net/~josephnewman/
Joseph Newman's Home Page

•http://www.overunity.de
Stephan Hartmann's Overunity Home Page

•http://www.angelfire.com/pg0/Newman/index.html
(A collection of reference material on Newman)

A Select Bibliography of Accessible Popular Articles on Joseph Newman's Energy Machine
(compiled by Eugene Mallove)

• "Newman's Impossible Motor," *Science*, Vol.223, 10 February 1984, pp.571-572.
• "Mr. Newman's Fantastic Machine," *Discover*, April 1984, p.6.
• "An Endless Siege of Implausible Inventions," *Science*, Vol.226, 16 November 1984, p.817.
• "Newman's Motor: Does It Work or Doesn't It?" *Science*, Vol.227, 29 March 1985.
• "A patent pursuit: Joe Newman's 'energy machine'," *Science News*, Vol.127, June 1, 1985, pp. 342-343.
• "A Man Who Defies the Laws," *Discover*, May 1987, pp.46-63.

THE FOLLOWING IS A SPECIAL REPORT CONCERNING THE ENERGY MACHINE OF JOSEPH NEWMAN

Evan Soulé
Director of Information
Newman Energy Products

[Editor's note: Mr. Evan Soulé, a long-time colleague of Joseph Newman, has provided *Infinite Energy* with the following report. In future issues of the magazine, we will publish additional material from Mr. Soulé, Joseph Newman, and others —particularly experiments to replicate the Newman motor.]

••••

"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it." — MAX PLANCK

What I am going to suggest to you in this Special Report is more than simply 'a genuine improvement in electrical technology,' but rather a significant paradigm shift which may challenge some of the fundamental beliefs held today in electrical theory. While I don't know you personally, I am hoping that you, the reader, possess the gift of intellectual honesty, i.e., a willingness to look at the facts regardless of one's predispositions and/or prejudices.

My personal background is history and science, and I have devoted the past twenty years to studying the history of physics -- especially with regard to invention and the great difficulties major innovators have had in presenting their achievements to society. In many instances the history of physics (science) has taught me that "the greater the innovation -- the greater the resistance." This is very unfortunate for the progress of humanity.

I am hoping that the independence of your thinking will give you the freedom to view a new technology, a new paradigm -- with the open-mindedness and intellectual honesty of Planck's 'new generation.'

Allow me to present to you a sterling example of "intellectual dishonesty": this brief story involves a young upstart thinker by the name of Galileo Galilei and a most distinguished Professor of Philosophy at Padua University by the name of Cesare Cremonini. One may ask today, "Who is Cesare Cremonini?" Yet four hundred years ago, Cremonini was the well-known and famous professor and Galileo Galilei was a virtually unknown original thinker.

Once upon a time (so the story goes), this young thinker Galileo claimed to have discovered "mountains on the moon" by virtue of the utilization of a new tool called the telescope. Naively believing that other thinkers and professors would welcome this discovery, Galileo invited professor Cremonini to view these moon mountains for himself through the telescope.

Cremonini chided Galileo for his insanity since, as everyone knows, "the moon cannot contain protuberances or blemishes since Aristotle has said that the moon is a perfect sphere." Galileo replied, "I don't care what Aristotle said, simply come look through my telescope and see for yourself." "No, Galileo, my young friend," responded Cremonini, "I KNOW that there are no mountains on the moon." Professor Cremonini then opened the book of Aristotle to the appropriate page and 'proved' that Galileo could not possibly be correct.

But Galileo was insistent. "If you just look through the telescope you will see that Aristotle was incorrect," he said to Cremonini. Then Professor Cremonini responded by saying, "No Galileo, I will NOT look through that confounded tube of yours. But IF I did look and if I DID see mountains on the moon, then I would know that you have simply enchanted me." This, dear reader, is intellectual dishonesty.

I am asking you, the reader, in this Special Report to be willing to "look through the tube." And the "tube" here represents a new understanding of electromagnetism.

You may ask, "How could this be so?" One may maintain that in a post-Faraday electrical society, everything that can be known about electromagnetism is known. In response to this position, I ask that you consider the quotation of Charles H. Duell, Director of the Patent Office in 1899:

"Everything that can be invented has been invented."

But before I present an introduction to the new technology in question, permit me to introduce its inventor -- Joseph W. Newman. [In my study of the history of science, I have discovered a passion for biography, i.e., by knowing something of the inventor one acquires a much greater depth, richness and appreciation for the significance of the innovation. In addition, biographies allow the reader to learn something of the personal struggles of the great thinkers and inventors of history.]

Who is Joseph Newman? He is an original thinker who has educated himself over the past forty years in physics, chemistry, astronomy and many other areas which have intrigued him. The focus of his life has become his work in electromagnetics which he began developing over thirty years ago. And he is not a starry-eyed theoretician. Since he has made his living by inventing, he has discovered a need to remain grounded in reality, in practical applications of his concepts.

These quotations are from scientists who have endorsed Joseph Newman's work:

"The future of the human race may be dramatically uplifted by the large-scale, commercial development of this invention."

—Dr. Roger Hastings, Principal Physicist, UNISYS CORPORATION

"If the manner in which Joseph Newman conducted his experiments and the results were made known to the industrial or engineering community then, in my opinion, several companies and/or individuals possess the expertise and capabilities to construct the hardware required to fully exploit the apparent capability of his new concepts."

—Dr. Robert E. Smith,
Chief, Orbital and Space Environment Branch, George C. Marshall Space Flight Center, NASA

"You have opened an area in Astrophysics which may revolutionize the magnetic energy problems which is now the most paramount problem in future energy and space travel. I do believe with proper research funds, the results would not only be a great financial boom to your financiers, but would lead to developments that will be practical and beneficial to all mankind and develop a new step in science."

—Dr. E. L. Moragne, MORAGNE RESEARCH & DEVELOPMENT CO.

[Dr. Moragne was an electromagnetic pioneer in the development of the first atomic bomb.]

Better than 30 physicists, nuclear engineers, electrical engineers and electrical technicians have signed Affidavits attesting to the validity of his invention: an electromagnetic motor/generator that could supply every American's home, farm, business, automobile and appliance with electrical power at a fraction of the

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present cost.

But before I discuss the invention itself, permit me to digress a moment about magnetism. Over the years I have posed this questions to professors of electrical engineering: "What is the mechanical essence of magnetism?" The standard reply is vague at best, but includes such answers as, "It consists of lines of force and action at a distance; potential energy."

The fifth edition of the *Modern Dictionary of Electronics* by Rudolf F. Graf [published by Howard W. Sams & Co., Inc., Indianapolis, Indiana] defines magnetism as:

"A property possessed by certain materials by which these materials can exert mechanical force on neighboring masses of magnetic materials and can cause voltages to be inducted in conducting bodies moving relative to the magnetized bodies."

And, lines of force are defined as:

"In an electric or magnetic field, an imaginary line in the same direction as the field intensity at each point. Sometimes called a maxwell when used as a unit of magnetic flux."

These definitions seem superficially fine, but fail to specifically address the real question: "What is the mechanical essence of magnetism?" "Of what do these 'imaginary lines of force' consist?" "What is the real nature of mechanical force -- what physically causes such action at the most fundamental level?" These questions perplexed Michael Faraday, who said: "How few understand the physical (emphasis added) lines of force! They will not see them, yet all the researches on the subject tend to confirm the views I put forth many years since. Thompson of Glasgow seems almost the only one who acknowledges them. He is perhaps the nearest to understanding what I meant. I am content to wait convinced as I am of the truth of my views."

[Although he had only a 7th grade, formal education, Faraday was a mechanical genius.]

I must postulate that if Faraday were alive today he would claim that because of the manner in which electric motors are constructed today — utilizing high current and low voltage — we have yet to discover the true nature of electromagnetism.

Joseph Newman unequivocally states that all electrical motors built to date are constructed with built-in inefficiencies since they should be operating with low current and high voltage. [But I am jumping ahead of myself at this point.]

Back to Faraday . . . One man truly understood Faraday's mechanical genius and was capable of translating his mechanical work into mathematics: James Clerk Maxwell -- a towering genius and innovator in science. Maxwell specifically wrote the following:

"The theory I propose may . . . be called a theory of the Electromagnetic Field because it has to do with the space in the neighborhood of the electric or magnetic bodies, and it may be called a Dynamical Theory, because it assumes that in that space there is matter in motion, by which the observed electromagnetic phenomena are produced." (Emphasis added.)

Maxwell even went on to add:

"In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. *The energy in electromagnetic phenomena is mechanical energy.*" (Emphasis added.)

Matter in motion. Back in the early 1960's Joseph Newman wondered what was the mechanical essence, the nature, of this "matter in motion." In Chapter Two of his book -- THE ENERGY MACHINE OF JOSEPH NEWMAN -- Joseph Newman describes the fundamental essence of a magnetic field as a particle having a "gyroscopic spin." This gyroscopic action is fundamental to understanding the mechanical nature of electromagnetism.

When one understands the gyroscopic characteristics of the matter in motion contained within an electromagnetic field, then one begins to recognize a better mechanical means of harnessing this kinetic energy. To generate the largest possible magnetic field within a copper coil and therefore to have access to greater numbers of "matter in motion" -- (for purposes of simplicity of understanding, Joseph Newman refers to this matter in motion as gyroscopic particles) -- one must input large amounts of voltage to achieve maximum atom alignment in the copper coil. When this high voltage input occurs, the copper coil atoms release their kinetic energy in the form of a magnetic field.

Joseph Newman has discovered a highly efficient means to harness this magnetic energy emanating from the copper coil. And Joseph Newman takes this a step farther by stating that these gyroscopic particles represent the mechanical essence of Einstein's equation of $E=mc^2$. He states that these gyroscopic particles spin at the speed of light and move in a given direction (lines of force) at the speed of light, and are thus the mechanical equivalent of $E=mc^2$.

Nearly twelve years ago, it took me about three weeks to really understand Joseph Newman's mechanical explanation of magnetism. I repeatedly studied the diagrams until I grasped what he was trying to say. As a result of understanding his explanation of magnetism I observed a simple magnetic phenomena which was elegantly explained by Joseph Newman's mechanical work in magnetism (see Chapter Three of his book).

I submit the following quotation from Ken Arno, Research Director at G.E.R.D., Co.:

"I can speak with a ' personal knowledge' and 'hands-on-experience' when I talk about the collapsing magnetic field phenomena in a coil. We here at G.E.R.D. Co. and everyone else who makes use of electrical circuits have always considered the collapsing field effect to be a nuisance because, when using a mechanical relay coil in an electronic circuit, it would cause a current to be pumped back into our circuit, creating havoc.

"One solution to the problem of C.E.M.F. was to install a diode across the coil leads and when the power was removed, the C.E.M.F. caused a current to flow which passed through the diode and to be dissipated as heat in the coil itself and not in our circuit.

"The fact that this effect has for over one hundred years been viewed as a problem to be designed out of electrical systems is the reason no one until you, Joseph Newman, had seriously considered it as a source of abundant free energy. Everyone knew it was there, but no one recognized its potential."

I submit the following from a Letter to the Editor of the *Mobile Press Register*:

"Never having met, talked with, nor had financial dealings with Joseph Newman, I read his book, *The Energy Machine of Joseph Newman*. After 30 years in the electrical profession I felt eminently qualified to debunk his claim to a device that generated more energy than it consumes. In the second chapter, I sat up in bed and shouted, 'He's got it!'"

--- Patrick McLain, Mobile, Alabama

I don't wish to dampen Mr. McLain's enthusiasm for this technology and, although his comments are well-intentioned, Mr. McLain is laboring under the superficial conclusion that Joseph Newman's motor "generates more energy than it consumes." This is simply not the case. In fact, the motor does generate greater external energy output than external energy input. This technology does not violate the Law of Conservation of Matter and Energy. On the contrary -- this technology further corroborates the Laws of Thermodynamics, i.e., the only way one will achieve the internal production of energy within the system is by supplying the system with high voltage (and low current) to align the copper atoms in the coil.

Joseph Newman supplies an external electrical stimulus to his coil (and special commutator system) that generates the magnetic field containing the gyroscopic particles (matter in motion). This external electrical stimulus takes the form of high voltage -- and the higher the better until maximum atom alignment of the coil is achieved. At the same time the current is kept as low as possible to minimize resistance; thereby the Newman motor always runs "cool." The externally applied high voltage is not "consumed" by the system — it operates in the same manner as the hydraulic system in an automobile. The reservoir of brake fluid is not "used up" but supplies a continual hydraulic pressure to the automobile's brake system. In a similar fashion the high input voltage (and low current) acts as an electrical 'hydraulic' pressure to continually realign the atoms within the motor's copper coil. The continual collapse and expansion of the copper coil's magnetic field creates the mechanical torque of the motor. (The special commutator system achieves this continual collapse and expansion of the magnetic field.)

The net increase of external electrical energy from the system directly comes from the energy produced internally within the copper coil. This net energy is greater than the small amount of current originally inputed into the system along with the high voltage. In the final analysis where is the excess energy coming f r o m ? Answer: from the atoms of the copper coil within the motor/generator.

Dr. Roger Hastings, a physicist who has worked extensively with Joseph Newman over a number of years, has calculated that this system is so conversion efficient that it may take decades (or far longer) to be able to measure any appreciable mass loss in the coil.

This brings me to a discussion of efficiency. If Joseph Newman's motor/generator system is viewed as a whole -- considering both external energy and internal energy -- then the total energy output for the system is equal to the total external and internal energy input combined.

Such a process is fully in accordance with the First Law of Thermodynamics! When the system is viewed as a whole, it is imprecise to say that the Newman motor/generator simply "produces more than it consumes." However, it is correct to say that "the external energy output is greater than the external energy input" -- an external energy input considered independently of the large internal energy produced by the Newman motor/generator.

In other words, the revolutionary nature of this system is the fact that Joseph Newman has discovered a new electromagnetic principle of nature and has innovated a technology capable of converting matter (copper coil) into energy (in accordance with $E=mc^2$) via a highly efficient electromagnetic reaction rather than an inefficient fission reaction.

Those who state that "one can never build a device which exceeds 100% efficiency" do not understand the nature of the phenomenal efficiencies (in excess of 800%) produced by the Newman motor/generator.

Such a statement demonstrates an inability to distinguish between CONVERSION efficiency and PRODUCTION efficiency. To state that Joseph Newman's motor/generator is 8.2 production efficient, i.e., that it produces over eight times as much external energy output as external energy input, is different from stating that the invention approaches 100% conversion efficiency, i.e., that it converts the internal mass of the copper coil into energy in accordance with $E=mc^2$. The former process involves production efficiency and the latter process involves conversion efficiency. These two different types of efficiencies should not be confused.

In his motor/generator system, the electromagnetic conversion (of matter to energy) efficiency approaches 100% [rather than the less than 1% conversion (of matter to energy) efficiency of a typical nuclear fission reaction.] The production efficiency of the Newman energy machine has been found to be in excess of 800%, i.e., over eight times as much external energy output as external energy input.

Consider the following crude analogy of a nuclear fission reactor to Joseph Newman's motor/generator: a typical nuclear reactor consists of a small amount of external electrical energy being inputed into the reactor station to turn on lights, activate control panels, start machinery, etc. The large external energy produced by the reactor, however, is the result of the nuclear fission process which internally occurs within the system.

As a result of such an internal fission process, external electrical energy is produced in the system. If, however, one ignores the internal energy and only considers the initial, small external energy input, then one could say that the net external electrical energy output produced by a nuclear reactor is greater than the external electrical energy input.

The important distinction, however, between a conventional nuclear reactor and Joseph Newman's motor/generator is that the former is less than 1% con-

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version efficient and the latter approaches 100% conversion efficiency.

In essence, Joseph Newman has integrated the work of Faraday with that of Einstein and has created a motor technology that will bring us into the 21st century. One may say that "this is too good to be true."

Is this -- our current electrical technology -- the BEST that we can do? Is there no expectation that we may achieve a deeper understanding of electromagnetism which will allow us to build fundamentally different (and more efficient) motors? Could one not conceive that such a revolutionary technology could be achieved in fifty years? One hundred years? One thousand years? Can anyone really believe that our traditional motor/electromagnetic technology is the technology that will be utilized five thousand years from now?

But why must we wait five thousand years? Why not in a hundred years? Why not in fifty years? Why not NOW.

You may say, "Well, why hasn't it been done before now?" My response: why did the Wright Brothers 'wait' until 1903 to invent the aeroplane? Things happen when they do, I suppose . . . often in spite of tremendous ignorance, apathy and hostility.

Christian Morgenstern summed it up quite well when he said:

"The obvious is that which is never seen until someone expresses it simply."

In its essence, Joseph Newman's technology is the model of simplicity.

Since 1979, Joseph Newman has spent over $1,000,000 in legal fees battling U. S. patent office bureaucrats in an effort to secure a patent for his revolutionary invention.

The Wright Brothers had to battle Patent Office bureaucrats all the way to the Supreme Court to secure a patent for their invention since they were told that it was impossible for man to fly in a "heavier-than-air machine."

On Thursday, August 10, 1995, Joseph Newman demonstrated his newest production model of his motor/generator: from 8:00AM to 8:00PM -- and attached to a Grainger Reciprocating Pump -- the Newman Motor/Generator pumped 1 gallon of water per minute at 12 PSI at the Lucedale, Mississippi City Park. The voltage source was a local alternating current connection to the Newman Motor /Generator through a conventional house watt meter. The Newman Motor /Generator utilized the city grid voltage but not the current. When a conventional motor was operated on this city grid system the house watt meter proceeded to turn, indicating that external electrical energy was being consumed.

During the entire 12 hours that the Newman Motor/Generator pumped water, the house watt meter did not move. Moreover, for the entire 12 hour period the Newman Motor/Generator ran cool. The news media, city officials and representatives of the local power station observed and corroborated these results.

This technology is ready to go forward into production.

WHAT CAN YOU DO?

• 1) Tell your friends and associates about the new technology.

• 2) If you are mechanically inclined and have at least a fundamental understand of electrical circuitry, you are invited to construct a prototype for yourself and demonstrate the remarkable nature of this technology. An 8-year-old girl built a small prototype of the Newman Energy Machine and won 1st place in her science fair! [Of course, the fact that her father was an electrical engineer probably didn't hurt!]

We recently received a VHS tape from a mechanically-gifted individual in Philadel-phia who constructed a Newman energy machine from having read the book, THE ENERGY MACHINE OF JOSEPH NEWMAN. We had no prior contact or knowledge of this individual, yet he corroborated Joseph Newman's results. This VHS tape is featured on a special VHS tape recently produced (see below)

• 3) We are looking for manufacturers who would be interested in producing Newman Motor/Generators. Contact the address below.

• 4) We are building up a list of mechanically-gifted individuals such that, as manufacturers begin to generate this technology, they will have a pool of individuals to draw from who are familiar with Joseph Newman's work.

• 5) Joseph Newman's fundamental, 450-page, hardcover book ($74.95), 7th Edition [ISBN: 0-9613835-7-7] which features over 150 illustrations, charts, graphs, and photographs can be ordered from: Joseph Newman Publishing Company, Route 1, Box 52, Lucedale, Mississippi 39452. This book represents over thirty years of research on the part of Joseph Newman. In some cases, you can ask your library to purchase this book, or, since many libraries across the country already have earlier editions which you can borrow via interlibrary loans.

• 6) Obtain a copy of the recently-produced VHS tape of the Special Demonstration on February 5, 1996 at the Adams Mark Hotel in Mobile, Alabama. This VHS tape ($30.00) available from Joseph Newman Publishing Company, features the Philadelphia version of Joseph Newman's energy machine, as well as considerable additional information. Also on the tape is a simple, inexpensive and repeatable demonstration that would make an excellent student project for a science fair. This demonstration proves conclusively that traditional electrical engineering has been harboring a 150-year-old fallacy that has resulted in all motors being constructed with built-in efficiencies! This fallacy is the belief that the strength of the magnetic field surrounding a copper conductor coil comes from the input CURRENT. THIS IS FALSE! The strength of the magnetic field surrounding a copper conductor coil comes from the ATOMS OF THE COPPER WIRE contained WITHIN THE TURNS OF WIRE as aligned by the input VOLTAGE.....NOT the CURRENT. And the greater the input VOLTAGE (up to maximum atom alignment of the atoms in the copper coil) the stronger the magnetic field surrounding the coil and hence, the greater the back-emf.

For additional information, contact:

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Washington Watch.....

More Garbage from the U.S. Patent Office - Circa 1996
An actual reply to a U.S. Engineer Filing a CF Excess Energy Claim

"Applicants arguments are unpersuasive. Upon reading applicant's claims in light of the disclosure, it is apparent that applicant's invention is a method of producing thermal energy in a cold fusion system. The specification on pages 3 and 4 for example, indicates that applicant's invention is a method and apparatus for potential commercial scale-up and use of "cold fusion" systems...Thus, in determining whether or not applicant's disclosure is sufficient and enabling, it is necessary to determine whether or not such "cold fusion" systems actually are not operative and, that the alleged showings of excess heat produced in such cold fusion systems are not valid in view of experimental errors, etc. It remains the examiner's position that there is no reputable evidence of record to support any allegations or claims that in such systems, the production of "excess heat" or of the generation of energy, due to nuclear and/or chemical reactions are valid and reproducible, nor that the invention as disclosed is capable of operating as indicated and capable of providing a useful output (including producing enough heat to be useful commercially)."....."For a discussion of errors arising in cold fusion tests or experiments, note for example, the book, "Too Hot To Handle", by Frank Close."....."It remains the examiner's position that an undue amount of experimentation would be required to produce an operative embodiment of applicant's invention. The examiner has cited numerous documents showing that experimenters have obtained negative results using various types of cold fusion apparatuses, all based on the cold fusion concept set forth by Fleischmann and Pons." ....."To explain the null experiments there is one theory--the conventional theory of Quantum Mechanics, but there are a wide variety of theories to explain positive Cold Fusion results-can they all be valid simultaneously—if not, which should be rejected?"....."These references provide further clear evidence that no excess heat is generate in such 'cold fusion' systems nor is there any evidence of nuclear reactions taking place."

The brazen criminality of the patent officials in this matter is astonishing and will not stand. Warning: Time is running out for this clique of obstinate bureaucrats.— E. Mallove

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One Commutator System Design for the Energy Machine of Joseph Newman

NEWMAN
ENERGY PRODUCTS
Route 1, Box 52
Lucedale, MS 39452 USA
(601) 947-7147 • (504) 524-3063
email:
josephnewman@earthlink.net

"Flattened View" of Commutator w/Conductor Strips and Connections.
[This particular design is an apr. 18" long cylinder with apr. 10" diameter.]

This is one of actually many different possible designs.

® Prototype, 1979 © Copyright, 1986-1996
Joseph W. Newman All Rights Reserved.

The commutator cylinder is simply "coupled with" the same (extended) shaft of the magnet rotor.

COIL 1 — Capacitor — Capacitor — COIL 2

Dashed lines represent connections inbedded in plastic.

Dashed rectangles are negative conductor strips on opposite side of commutator.

As a rule of thumb, for every 40 lbs of wire one can have 20-30 lbs of magnets

Brush and wire to positive pole of battery (+)

Brush and wire to negative pole of battery (−)

Additional information about this technology is contained within the book, The Energy Machine of Joseph Newman [ISBN: 0-9613835-7-7; 7th Edition, 470 pgs, 160 drawings, $74.95] available from Joseph Newman Publishing Company, Route 1, Box 52, Lucedale, MS 39452 A 1hr/45min VHS tape [$30] which shows operational prototypes is also available.

While individuals may build a model of this technology for their own use, they may not manufacture and/or sell this technology to others without the express, written permission of Joseph W. Newman. All rights reserved.

Switch

Capacitors: Should be large, 20-40 lbs., available from elec. supply co. or Power Co.

BATTERY 2000 Volt DC

Joseph Newman sincerely asks you to Master his book and understand WHY this general design is used. Don't simply copy it like a "parrot". Such an understanding will enable you to visualize MANY different possible designs!

Newman Motor/Generator (1 Coil Design)

Original drawing by Ralph Chiocchio with amendments by Evan Soule', Jr.

The above design represents TWO separate commutators --- one going to each coil.

This particular model is 28 in. long. Magnet housing for wire = 4 7/8 ID After wraping wire, dip it in insulating varnish.

130# Magnet Rotor

Fiberglass or equivalent

Top View

FIGURE A

Wire to one-half of other side of commutator (+)

Wire to one-half of one side of commutator (−)

The injected-molded commutator would be attached to one end of the shaft or parallel to the motor.

The Newman Motor/Generator utilizes low current & HIGH VOLTAGE and operates COOL!

Magnets — N, N, N, S, S, S — Epoxy Fiberglass Filler (available at Walmart)

Magnets — Qualitative depiction of magnets [Magnet rotor CAN BE apr. 28" long. Designs may vary w/# of magnets.]

Wire

Bearing

Depicted in Fig. A is **one coil**. The system can also be designed with two (2) coils as depicted in the book, page 463. The dots distributed throughout the commutator design (above) represent wire connections to brushes and commutator copper segments to one another.

The magnets are applied relative to the width to the flat on the six-sided hex shaft. The magnets in this design are neodymiun 1/2 inch thick, 1-3/4 inch long and approx. 1-1/4 inches wide. One can use ceramic magnets, but one will need to make the motor larger. For magnet and wire sources, see the Manufacturer's Directory at any library. REMEMBER, THE BATTERIES ARE CONNECTED IN SERIES. THE SYSTEM IS DESIGNED TO UTILIZE HIGH VOLTAGE AND LOW CURRENT.

FIGURE B

(+) (−)

The additional coil system B(x) does the same as above in Figure A and is attached to other side of commutator

In Fig. B, **one additional coil** is shown at right angles to the original coil (depicted in Drawing A). **Two more** 200# coils can also be placed at 45 degree angles to coils shown and capacitors for Greater Output Power. The larger the unit is built, (the greater the number of copper atoms), the Greater the Power Output!

MAGNETS — Qualitative, not quantitative depiction — STEEL SHAFT — HOUSING & WIRE — BEARINGS

PARTS NEEDED FOR CONSTRUCTION:

1. Magnetic insulated wire [copper, 38 gauge, 140#, 56 equal lengths in parallel
2. Fiberglass or equivalent (spool wire is wrapped around) — made in two (2) equal halves, or better yet, made in 4 or 6 equal parts.
   Be sure to use capacitors. (Special design recently innovated.)
3. Two (2) bearings
4. One (1) Steel Shaft on which magnets are placed
5. Magnets (permanent, neodymium — 6-sided and neodymium magnets on six sides)

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REPLICATION OF THE APPARENT EXCESS HEAT EFFECT IN A LIGHT WATER - POTASSIUM CARBONATE - NICKEL-ELECTROLYTIC CELL

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ABSTRACT

Replication of experiments claiming to demonstrate excess heat production in light water-Ni-K_2CO_3 electrolytic cells was found to produce an apparent excess heat of 11 W maximum, for 60 W electrical power into the cell. Power gains ranged from 1.06 to 1.68. The cell was operated at four different dc current levels plus one pulsed current run at 1 Hz, 10% duty cycle. The 28 liter cell used in these verification tests was on loan from a private corporation whose own tests with similar cells are documented to produce 50 W steady excess heat for a continuous period exceeding hundreds of days. The apparent excess heat can not be readily explained either in terms of nonlinearity of the cell's thermal conductance at a low temperature differential or by thermoelectric heat pumping. However, the present data do admit efficient recombination of dissolved hydrogen-oxygen as an ordinary explanation. Calorimetry methods and heat balance calculations for the verification tests are described Considering the large magnitude of benefit if this effect is found to be a genuine new energy source, a more thorough investigation of evolved heat in the nickel-hydrogen system in both electrolytic and gaseous loading cells remains warranted.

BACKGROUND

Motivated by the possibility of a new and practical source of abundant energy, a growing flurry of activity continues around the world to replicate, control and understand the source of anomalous heat in the so called 'cold fusion' effect, first reported in March, 1989 by Fleischman, Pons and Hawkins(1) and also by Jones et al.(2) in electrochemical cells that load deuterium into metallic palladium or titanium. The initial disappointment at lack of experimental reproducibility has by now been compensated to a fair degree by the realization that special and usually difficult to achieve conditions(3) are necessary before the Pons-Fleischman effect can be observed. For example, it is now known that a high D/Pd loading ratio is one such difficult necessary condition and that likely there are others. Thus in the EPRI program(4) on deuterated metals, McKubre et al. report(5) that in a batch of Pons-Fleischman type cells, carefully prepared for precision calorimetry, every cell achieving a D/Pd≥0.95 showed excess heat, whereas none did that had a D/Pd<0.90. This and other effects, such as the frequently long time delay to onset of excess heat, were not fully appreciated at the time of the initial high profile, negative follow-up reports from Harwell(6), Caltech(7,8), and MIT(9); moreover, some of this work was done in haste and under great pressure of public scrutiny. These early follow-up reports may now be mostly of historical interest, as controversy regarding their calorimetric(l0) and data reduction(11) methods has been raised

Modern cells of various types have been reported to produce 50 W or more of excess power for hundreds of days, to have power multiplication factors over 10, and to achieve specific powers as high as 4 kW/cm^3 (12). If true, such data clearly exclude by orders of magnitude an ordmary chemistry explanation and force one to consider various lattice assisted nuclear channels, or exotic quantum chemistry (electron transitions catalyzed to unusual, deep atomic levels (13, 14, l5, 16) and also the subsequent fusing of the "shrunken" atoms), or the even more exotic possibility that somehow space energy, such as effects of the electromagnetic zero-point fluctuations, is involved.

It seems fair to say, however, that many still doubt the quality of evidence for the existence of consistent anomalous heat, citing the sporadic reproducibility and paucity of compelling evidence. Nevertheless, current experimental emphasis is shifting away from mere replication of the basic effect to developing it in diverse embodiments such as cells based on gas phase interactions with certain metals, light water-K_2CO_3-Ni, molten salt electrolytes, proton conductors, etc. Such alternatives may offer specific advantages for the generation of power and understanding of the underlying mechanisms. For an overview of the latest experiments and the diverse contending theories, the reader may peruse the series of Proceedings of the nth International Conference on Cold Fusion (lately ICCF4 and ICCF5).

THE LIGHT-WATER CELL TESTED AT NASA

If the anomalous heat effect is found to be genuine, then it may be useful as a power source to replace radioisotope thermal generators for planetary spacecraft or other applications. An opportunity arose in 1994 to obtain, on loan from the Hydrocatalysis Power Corporation, a light-water cell for verification testing. The relative simplicity and reliability of the light water-Ni-K_2CO_3 electrolytic cell made it particularly attractive for startup experimentation into this anomalous heat effect. *[Editor's note: See article on Hydro-Catalysis Power Corp.* ***IE #5&6****, pp.57-58.]*

The existence of an excess heat effect in electrolytic cells based on a platinum (coated) anode and a nickel cathode immersed in a light-water solution of K_2CO_3 was first reported by R.L. Mills and S. P. Kneizys(16), although the possibility was stated earlier by S. Pons et al. in a patent application (17). The effect was soon verified by V.C. Noninski (18) and continues as an active topic of research at numerous laboratories.

Prevailing experience has it that only rarely do the lightwater cells using either K_2CO_3 or Rb_2CO_3 fail to produce at least

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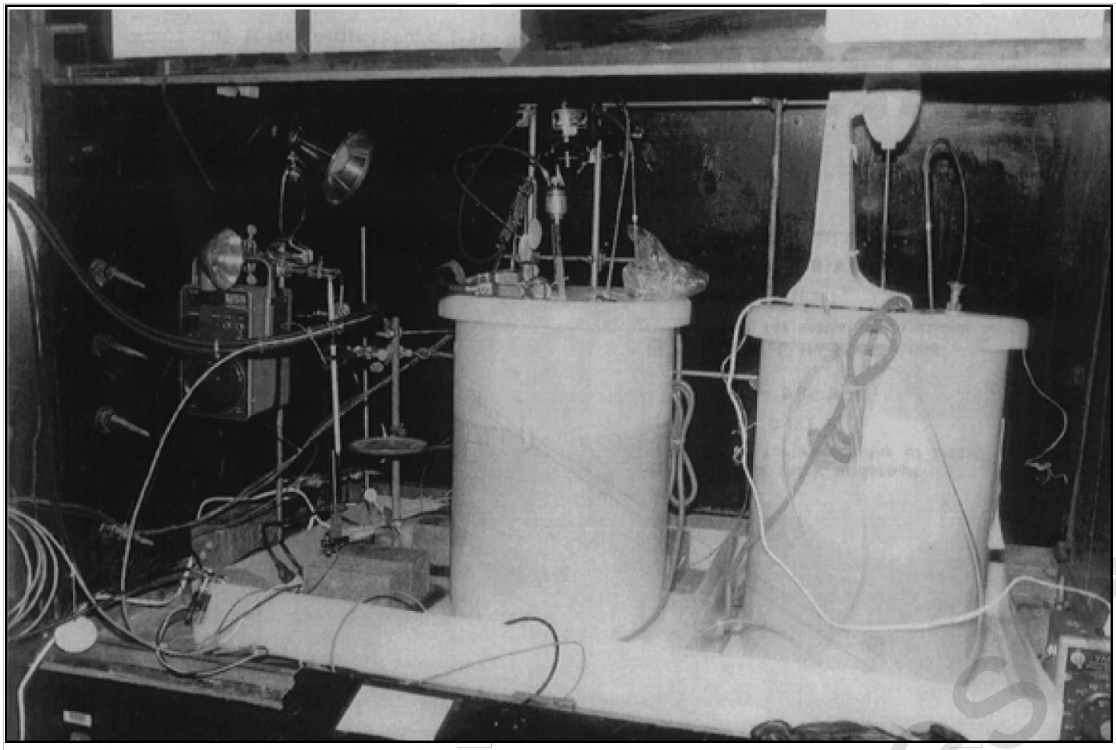

Figure 1. Active (left) and reference cells on the floor of a hood. During operation, the lower sash of the draw window was kept at a height even with the tops of the cells, giving a window airflow of 0.7 m/s.

some apparent excess heat immediately upon electrolysis, although full power may take months to develop. In contrast, cells based on Pd and D_2O often remain inactive for many days and require very careful selection and loading of the Pd.

The cell obtained was a rather large sized demonstrator, operating with 28 l of 0.57 M K_2CO_3 solution in deionized, but otherwise ordinary, water in a 10-gal. polyethylene tank (Nalge 5410-0010). Its anode was a set of 10 platinized 1.6"x 10" titanium strips and 5 platinized l"D x 8" titanium tubes. And the cathode consisted of 5000 m of 0.5 mm D cold drawn nickel wire, wound as 150 sections, each 33 m long, on a perforated, 5 gal. polyethylene bucket. The 15 anode sections were suspend in a circular array close to the inner wan of this bucket from a 12 1/4" D polyethylene disk covering the top of the bucket and located several inches above the liquid level. Cathode and anode connections were brought out from the air space between the disk and the outer lid by means of two 1/2" D x 4" plated steel carnage bolts. Small holes were available in the outer lid and in the disk for insertion of the rod of a stirring paddle and thermocouples into the volume of the inner bucket. This cell came equipped with a 57.6Ω, l000 W, incoloy cased and teflon jacketed heating rod for on-the-fly calorimetric calibration.

Another cell, identical except for a missing anode structure, was obtained to provide a stable ambient temperahlre reference by averaging the short-tenn air temperature fluctuations.

The cell tested at NASA is thus nearly the same as the one pictured and described in more detail under "Thermacore Experiment 4" in Reference 15, except that the Thermacore cell used an additional, inner cathode wound from 5000 m of nickel wire.

EXPERIMENTAL SETUP AND PROCEDURES

The two cells, the active one on the left and blank reference on the right, were placed side by side in a hood, as shown in Figure 1, with their centers about 48 cm apart and 33 cm behind the draw window. Both cells sat on top of identical, 1" thick, closed cell, plastic foam pads placed in plastic trays; pad compression over the weeks of operation was minor. During operation, the bottom edge of the hood draw window was kept at a fixed madc, level with the tops of the cells. In this way the cells were equally cooled by a steady, 0.7 m/s breeze driven by the hood fan, reducing the vagaries of air convection and variation of cell thermal conductivity with cell temperature. Room temperature variations were moderated only by the basement location, as no thermostatic control was available. Although room air temperature variations up to a few degrees C were experienced during some days, their effect appeared to be well canceled by referencing the active cell temperature rise with respect to the thermally matched blank cell. This room temperature instability unfortunately did make it difficult to obtain reliable data of cell thermal conductivity directly with respect to the ambient air at heater powers below 50 W. No experiments were performed involving electrolysis action in both cells simultaneously (such as comparing the action of K_2C0_3 and Na_2CO_3 solutions in the two cells operated in series) because our blank had no anode.

During steady dc electrolysis, all data was recorded on a Yokogawa model HR2300 multichannel stripchart recorder. This instrument can resolve 0.1°C using type T thermocouples on any channel programmed for temperature. The actual thermocouple wire used was type T duplex, teflon covered and of enhanced accuracy, obtained from Omega Engineering, Inc. and labeled as "special limits of error." With this wire, the 3 thermocouples used to measure the electrolyte temperature near its center, top, and bottom were found to track each other within 0.1°C from room temperature to 72°C. In all, 5 temperature probes were monitored: air temperature at hood entrance, active cell electrolyte temperature at three depths, and blank cell water temperature at mid depth. The average of the 3 electrolyte temperatures was computed by the HR2300 and also recorded, as was the difference between this average and the blank cell temperature. All immersed thermocouples were electrically isolated from the electrolyte by 6 mm OD (3.5 mm ID) glass tubing, fused shut at one end.

The dc voltages of interest, ie. at the cell and heating rod tenninals as well as from current shunts, were routed to the HR2300 and recorded individually. Electrolysis current was sensed by a 1 mΩ precision shunt and the dc powered heating rod current was sensed by a 66.67 mΩ precision shunt. Power computations were done by multiplication and scaling internal to the HR2300 and the results were recorded. A check with a Racal-Dana Series 6000 digital multimeter revealed that the voltage and power values displayed digitally by the TR2300 were accurate to at least ±0.1%. All the HR2300 input channels were operated floating differential. Also, the output of the 6 V, 50 A electrolysis power supply, a Kepco model ATE6-50M, was entirely dc isolated. With these precautions, the chance of any significant ground loop induced error was minimal.

Since the thermal time constant of the cell in the setup was observed to be 5.5 hours, uncontrolled drift of environmentally sensitive parameters could waste many hours of running time and create errors. Primarily this involves control of the heater and electrolysis powers. In the case of electrolysis power, it seemed best for two reasons to fix the cell current and let the voltage drift with the cell temperature. First, at a nonnal operating point, the cell differential resistance is low, meaning that the current will be very sensitive to small changes in cell voltage or temperature, making control by voltage difficult. Second, one expects any excess heat to basically depend on the current, because the rate of delivery of hydrogen ions to the nickel surface is proportional to the cunrent.

The heater rod in the active cell was used to develop the curve of temperature rise ΔT, as referenced to the unheated blank cell, versus ohmic power dissipated in the active cell by observing the steady state ΔT at selected heater powers. The slope of this line is just the thermal resistance of the cell and the process of generating such a line during electrolysis is called calibration on-the-fly(l5,16). An on-the-fly calibration is necessary, for as will be shown, the effects of electrolysis can significantly affect the cell thermal resistance.

To keep heater power constant, even as the heater resistance or supply voltage varies, we used a precision constant power controller. This was a circuit based on analog multiplication and feedback techniques controlling a series-pass power MOSFET and similar to load controllers described by J.M. Niedra(l9). Using a 100 V dc supply, any preset power up to 120 W and stable to within ±0.5% could easily be delivered to the heater.

During the regular runs, the active cell was stirred continuously by means of a small teflon half-moon attached to the end of a glass rod rotating at a constant 250 rpm, but the blank cell was stirred only intermittently to eliminate the 0.5°C or so temperature stratification that could be seen in the water if left undisturbed for a day. Preliminary experiments with the unheated blank cell had shown that in an undisturbed cell suddenly so stirred, any small temperature nonunifonnity returned to within 0.1°C in a minute or two. Further, even after 27 hours of stirring at 315 rpm and with the hood fan off, no clear temperature rise above ambient could be resolved (0.1 to 0.2°C). Hence the paddle arrangement and its 250 rpm speed was judged entirely satisfactory, producing a negligible contribution to the steady ΔT.

Pulse mode control of the electrolysis current has been claimed to increase the ratio of excess heat to input power, both in D_2O-Pd(20) and H_2O-Ni cells(15). We tested this mode, as time permitted, for at least a 1 Hz pulse repetition rate at 10% duty cycle. The above mentioned power supply was found to be a good source of sharply rectangular current pulses, when operated in its voltage programmed current mode, with peak current set by the current limiter. Current-to-voltage conversion was done by a 0.010 Ω shunt, whose perfonnance with pulses was verified by comparison to a high speed current probe. To simultaneously record the rectangular cell current pulses and associated terminal voltage, we used two Tektronix type 11A33 differential comparators in a DSA602A digitizing oscilloscope mainframe. The instantaneous product of cell current and voltage was recorded as well. Also, null input recordings were taken immediately after a data recording in order to correct for dc offsets in the

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11A33s, which were observed at times to be as much as several percent of the signal amplitude. Null recording provided the only means of baseline correction for the cell voltage waveform record, because the cell voltage did not decay to zero during the cycle. As a check on the digitized data, time averaged cell cutrent and voltage, formed by 100 s time constant RC networks, were recorded with the HR2300.

ANALYSIS OF DATA

Blank cell thermal conductance

One expects to observe some differences in the steady state heat loss characteristics, or thermal conductance κ, of the blank cell and the active cell during electrolysis. Additional water vapor being carried away in the evolved H_2 and O_2 gas bubbles may well contribute an extra heat loss during electrolysis. And as the electrolysis current is increased, the evolving gases may conceivably contribute to a decrease in due to their insulating effect. The heat loss contribution to κ arising from the specific heats of the H_2 and O_2 seems negligible, however, being only about 2.16×10^{-4} $WA^{-1}{}^{\circ}K^{-1}I$, where I is the electrolysis current. Thus for I=10 A, this additional loss is only a few milliwatts per °K This heat loss has been estimated using the gas specific heats c_p of 28.7 and 26.0 Joule/(mole°K) for H_2 and O_2,(21) respectively, and assuming 100% Faradaic efficiency. Finally, the welding cables clamped to the electrolysis electrode tenninals may have contributed a slight additional, temperature dependent heat loss to the active cell. This effect too seemed to be minor, as the temperature rise of the top of the cell was always much less than that of the liquid contained below. In any case, all heat losses for the active cell are automatically included by the on-the-fly calibration.

A number of heat loss calibration runs were performed with the blank cell, loaded with 28.0 liters of deionized water. This amount of water contributes 1.17×10^5 J/°K to the heat capacity, whereas the 8.75 kg of Ni wire contributes only 3.88×10^3 J/°K, with contributions from the other cell hardware being negligible. At least 24 hours were allotted for the cell to reach equilibrium temperature at each of the heater powers set by the precision controller.

The result of the first 4 blank cell heat loss calibration runs is represented by the lower line in Figure 2, which has a reciprocal slope of κ_{bl} = 6.13 W/°K The 3 lowerpower points are seen to be very well aligned with the origin, but the 125 W point droops slightly. The reason for this droop was thought to be the onset of more rapid water vaporization at the 43°C temperature of the 125 W point. Therefore a straight line through the origin was fitted to the 3 lower points only. No points below 50 W were taken because of lack of time and the observation that the 1/4 inch thick, plastic underpad used initially had compressed to an unacceptably thin 1/8 inch under the weight of the cell. Thereafter a 1 inch thick plastic foam underpad was substituted, which suffered only minor relative compression. The upper straight line through the origin in Figure 2 represents the new characteristic, again ignoring the 125 W point. Now the reciprocal slope is a slightly lower κ_{bl}=5.85 W/°K, which is the same as the 0.17 °C/W on-the-fly coeffficient at I_C=50A given for the Thermacore experiment no. 4. Unfortunately the 75 W point turned out to be the lowest power data obtained with the thicker pad, because lack of time and an unstable room temperature caused by weather made it impossible to take accurate low power points.

In spite of the lack of lower power calibration points, the good alignment with the origin of the points obtained (except for the highest power ones) is evidence that K is a constant for ΔT below about 17°C. The purpose of setting the cells in a vigorously and uniformly flowing airstream was of course to reduce any temperature dependence of κ. As seen below, a highly temperature sensitive κ invalidates, or at least complicates, the usual regressive extrapolation toward the origin in order to find the excess heat.

The presence of additional heat loss channels induced by electrolysis necessitates on-the-fly thermal characterization of the active cell. However, this method has a lower limit on power for a given electrolysis current, because this current dissipates ohmic heat in the electrolyte. Nevertheless, lower ohmic heat points were obtained in some electrolysis runs and these support the constancy of K with ΔT. The active cell runs also exhibited quite clearly a small, but not insignificant, dependence of κ on the electrolysis current. The blank cell calibration line serves merely as a limiting low current check on the active cell thy behavior.

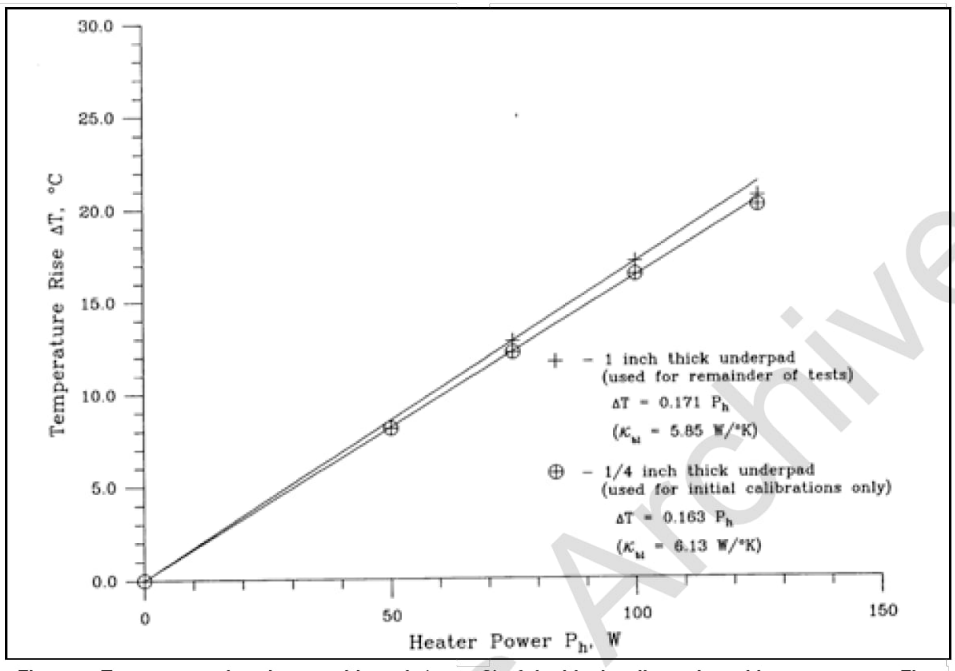

Figure 2. Temperature rise above ambient air (~ 23 °C) of the blank cell at selected heater powers. Fits are least squares straight lines through the origin. ignoring the 125 W points, which appeared to be dropping due to the increased water vaporization at their temperature (~43°C).

Heat balance and the excess heat effect

Figure 3 defines the various input and output powers to the cell viewed as a box enclosing unknown and certainly complex processes. There are only two unquestionably significant power inputs, namely the cell terminal power $P_c=V_cI_c$ and the heater power P_h. Note that resistive drops in connections internal to the cell might make the power delivered to the electrolyte slightly less than P_c. Thermoelectric pumping of heat through the electrolysis terminals by the Peltier effect is a consideration that has been drawn as an input power P_{te}. The experimentally negligible Joule heat input P_{st} due to stirring is drawn there also.

The temperature rise dependent heat losses consisting of convection, water vaporization and various conductions are lumped into a thermal loss P_{th}, which is just $\kappa\Delta T$ if the process is linear over the ΔT range of interest here. The remaining loss is the energy carried away by the H_2 and O_2 gases escaping the celL This loss amounts to the energy 4.75×10^{-19} J/molecule of H_2O that could be retrieved if the gases were recombined and condensed to liquid H_2O at the same temperature. When calculated in terms of I_c, this energy corresponds to the thermnoneutral voltage of 1.48 V and the 'gas power' is written as 1.48 ηI_c where the Faradaic effficiency η may be less than 1 to cover the case of a partial recombination of the H_2 and O_2 within the cell.

The excess heat P_{exc}, if any, is simply the difference between the total output and input powers and can be written as

$$P_{exc} = (P_{th}+1.48\eta I_c)-(P_c+P_h+P_{te}+P_{st}) \quad (1)$$

To be useful for computing P_{exc}, Eq. 1 must be put into a form that relates closer to what is measured. First we note that the thermal heat loss $P_{th}=P_{th}(I_c,\Delta T)$ is an unknown function, but with the property that $P_{th}(I_c,0)=0$. The simplest such admissible form is $P_{th}=\kappa(I_c)\Delta T$. Information about this function must be gleaned experimentally, say by varying P_h. with I_c fixed. P_c will then vary also, since the V_c versus I_c characteristic is temperature sensitive. Nevertheless, one can combine some of these variables into a single term

$$P_o \equiv P_c+P_h+P_{te}+P_{st}-1.48\eta I_c \quad (2)$$

representing the part of the total input power that is dissipated as heat in the electrolyte. For a fixed I_c, P_h=0 gives the least possible P_o. Even if P_{te} and P_{st} are negligible, the possibility that η<1 cannot be ignored. Therefore it is convenient for plotting purposes to define a 'reduced' dissipated power

$$\tilde{P}_o \equiv P_h+P_c-1.48I_c \quad (3)$$

that underestimates the true dissipation, but is completely determined once P_h and I_c are set. With this definition,

$$P_o \equiv \tilde{P}_o+P_h+P_{te}+P_{st}+1.48\eta_{rec}I_c \quad (4)$$

where

$$\eta_{rec} \equiv 1 - \eta \quad (5)$$

is a recombination efficiency. With these definitions, Eq. 1 becomes

$$P_{exc} = P_{th} - P_o$$
$$= P_{th} - \tilde{P}_o - (P_{te}+P_{st}+1.48\eta_{rec}I_c) \quad (6)$$

One can curve fit experimental data of steady state ($\tilde{P}_o$, ΔT), obtained by varying P_h at fixed I_c. This plot can then be extrapolated to ΔT=0 to obtain $\tilde{P}_o|_{\Delta T=0}$ = 0; the confidence one can place in this extrapolation depends

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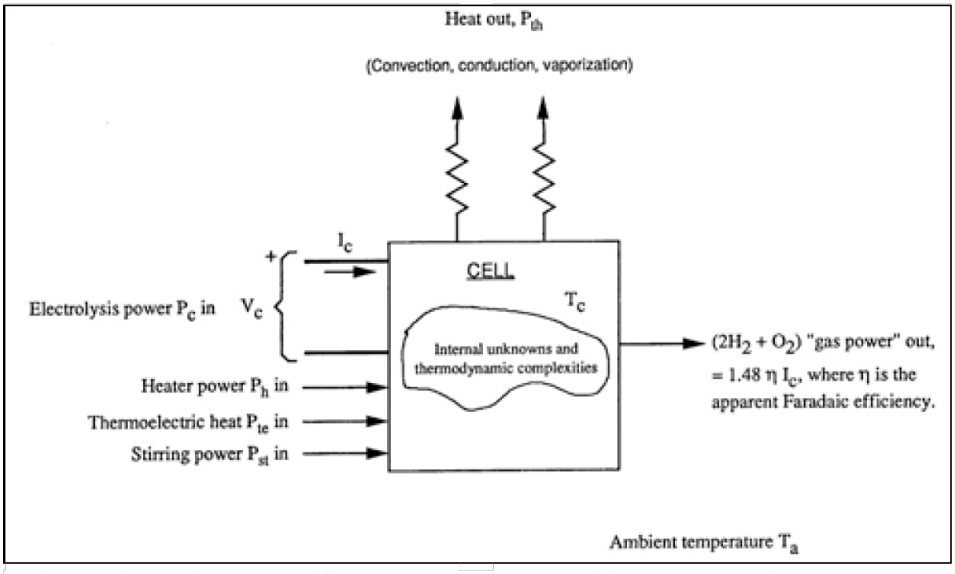

Figure 3. Identification of the cell input and output powers considered in the analysis of excess heat.

on the scatter of the data, the nature of the fitted curve and the closeness of the data to the origin. As mentioned, $P_{th}|_{\Delta T=0} = 0$ regardless of the particular dependence of P_{th} on ΔT. Thus fiom Eq. 6 and this property of P_{th}, it follows immediately that the true excess heat is

$$P_{exc} = (-\tilde{P}_{th}|_{\Delta T=0}) - (P_{te} + P_{st} + 1.48\eta_{rec} I_c) \quad (7)$$

in agreement with considerations in the literature.

If for fixed I_c the $\tilde{P}_o$ versus ΔT is a straight line, then $\partial \tilde{P}_o / \partial \Delta T$ is a constant and hence taking $\partial\ /\partial \Delta T$ Eq. 6 shows that $P_{th} \propto \Delta T$; this assumes that the terms P_{exc}, P_{te}, P_{st} and $1.48\eta_{rec}$ are constant with ΔT. Any intrinsic dependence of the heat production mechanism on AT or T is not revealed by the extrapolation.

A summary of the steady state ΔT versus P_o data obtained at fixed I_c = 5, 10, 20 and 40 A is presented in Figure 4; this data was obtained by varying P_h, as stated under Eq. 6 above. Straight lines gave excellent least squares fits to the data and their extrapolated P_o-axis intercepts are

$\tilde{P}_o|_{\Delta T=0}$ = -7.20, -8.57, -11.4 and -8.41 W corresponding respectively to the above I_c. If the terms P_{te}, P_{st} and $1.48\eta_{rec}I_c$ are negligible (P_{st} certainly is; see EXPERIMENTAL SETUP AND PROCEDURES), then, according to Eq. 7, these $\tilde{P}_o|_{\Delta T=0}$ are the positive excess powers corresponding to the above 4 dc I_c; however, the P_{te} and $1.48\eta_{rec}I_c$ contributions win be discussed.

In general, we shall call $(-\tilde{P}_o|_{\Delta T=0})$ the apparent excess power or heat.

Along with each data line in Figure 4, also the blank cell calebration line is redrawn to provide a comparison of their slopes. This comparison shows that $\kappa(I_c) > \kappa_{bl}$ in all 4 cases and that $\kappa(I_c)$) tends to increase slightly with I_c. A summary of this behavior of $\kappa(I_c)$ is presented as a scatter plot in Figure 5, that also includes the κ_{bl} data point as well as is from a pulse I_c ma plotted at its average current I_c=3.10 A.

Due to time constraints on laboratory space, the only pulse I_c data taken was with 30 A rectangular pulses at a 10% duty cycle and 1 Hz repetition rate, giving the mentioned average I_C=3.10 A. Values for the on-the-fly calibration plot were obtained by time averaging Eq. 3, etc.. From the corresponding line fitted in Figure 6, the apparent excess heat is found to be only 2.66 W. And the thermal conductance is seen to be very close to that of the blank cell, as already indicated in Figure 5. A sampling of the I_c, V_c and P_c waveforms recorded at thermal equilibrium and P_h=O is presented along side to show the cell polarization effect. The time averages $\bar{I}_c$ and $\bar{P}_c$ noted in Figure 6 include small corrections for baseline offsets in the DSA602A.

Internal recombination and water addition

Reliable data on water loss during electrolysis from cells operating without a recombiner is essential to the correct interpretation of the apparent excess heat, especially in low power cases having $-\tilde{P}_{th}|_{\Delta T=0} < 1.48 I_c$. In such cases a sufficiently high recombination efficiency η_{rec} can imply that P_{exc}=0 even if P_{te} and P_{st} are negligible, as inspection of Eq. 7 shows.

Unfortunately, the run time allotted to each constant heater power P_h was limited to at most a day or two, which precluded the taking of accurate water loss data in our setup. In efforts to compensate for data inaccuracies, a loss rate was calculated for each selected I_c by adding the loss amounts for all the corresponding runs of fixed P_h and dividing by their total time. This procedure reduces the data scatter at the cost of lumping together temperature dependent evaporation rates. Water loss rates so processed are plotted against I_c in Figure 8 and fitted by a straight line. 100% efficient (η=1) electrolysis would generate the loss rate αI_c where α=9.34x10^{-5} g s^{-1}A^{-1}, which too is plotted in Figure 8.

The total water loss rate is the sum of evaporation and electrolysis losses, or

$$\mathbf{L} = \mathbf{L}_{ev} = \eta\alpha I_c \quad (8)$$

where $\mathbf{L}_{ev}$, depends on T_c, and hence on I_c and P_h. However, only the I_c dependence of $\mathbf{L}_{ev}$ will be considered below, because for each I_c the P_h dependence has been 'averaged out' in the data of Figure 8. Evaporation dominates recombination in Figure 8, for the data fact that $\mathbf{L}_{ev} > \alpha I_c$ is the same as

$$\mathbf{L}_{ev} > \eta_{rec}\alpha I_c \quad (9)$$

Although our data is insufficient to place a hard upper bound on η_{rec}, a bound tighter than Eq. 9 can be had by substituting the experimental fit

$$\mathbf{L}_{ev} = \beta I_c + \mathbf{L}_{ev}(0) \quad (10)$$

where β=9.03x10^{-5} gs^{-1}A^{-1} and $\mathbf{L}_{ev}(0)$=3.78x10^{-4} gs^{-1}, into

$$\mathbf{L} - \alpha I_c = \mathbf{L}_{ev}(0) + (\eta-1)\alpha I_c \quad (11)$$
$$= \mathbf{L}_{ev} - \eta_{rec}\alpha I_c$$

$$\eta_{rec}\alpha I_c = \mathbf{L}_{ev}(I_c) + \mathbf{L}_{ev}(0) + (\alpha-\beta)\alpha I_c \quad (12)$$

This formula is useful, because at the lower I_c of the runs the contribution of the I_c to ohmic heating was small as compared to the upper P_h values over which the water loss data was averaged to obtain the points in Figure 8. Thus $\mathbf{L}_{ev}(I_c)$ cannot be much greater than $\mathbf{L}_{ev}(0)$ in the present case.

DISCUSSION

To claim the reality of excess heat in the presence of other comparable heat transfer processes, one must support the validity of the extrapolation to get the apparent excess heat $(-\tilde{P}_{th}|_{\Delta T=0})$. Both the blank and active cell thermal conductance data shows that these cells in the environment described are well charactenzed by a thermal conductance κ that depends slightly on the cell current I_c, but not at all on the temperature rise ΔT, at least for 0 ≤T≤17°C. The blank cell runs showed in particular that the lower ΔT versus heater power P_h points are well in line with the origin. This eliminates the possibility that the (ΔT, P_h) locus could curve into (0, 0) from above; multiple curvature inflections seem quite unlikely. Further, the active cell constant I_c runs show in Figures 4 and 6 that the thermal conductance characteristic is very linear down to total ohmic heatings of only a few watts, assuming negligible hydrogen-oxygen recombination. Hence there is good evidence for the validity of the linear extrapolation to ΔT=0 of our data.

Accepting the rationale for the apparent excess heat extrapolated from the on-the-fly thermal data, the burden is shifted to showing that the heat additions P_{te}, P_{st} and $1.48\eta_{rec}I_c$ cannot account for the apparent excess. These heats win be discussed below. Worthy of mention is also the possibility of corrections whose omission leads to an underestimate of the excess heat. Ohmic heat is generated in the wires and connections inside the cell, but above the electrolyte. This heat is included in P_c even though it is not wholly delivered to the electrolyte. Thus in the cell tested, some warming of the external anode terminal was evident for I_C>20 A, while the external cathode terminal remained at about the cell top temperature. Finally, any unrecognized mechanism of electrochemical energy storage is an error on the conservative side.

The stirring power P_{st} is not a contender in accounting for the observed apparent excess heat, because stirring induced ΔT was at the resolution limit, 0.1 °C, of the recorder. This implies a P_{st} below a watt on the blank cell calibration slope κ= -5.85 W/°C.

Handel (22) has recently proposed that the thermoelectric power P_{te} into an electrolytic cell may in some cases account for the claimed excess, mainly citing experiments exhibiting a proportionality between steady I_c and excess power. He justifies the required very high (for pure metals) effective differential Peltier coefficient $\Delta\Pi \approx 400$ mV by pointing to cases where the excess heat was observed for only a small fraction of the time. We contend, however, that several circumstances greatly reduce the likelihood of, if not entirely eliminating heat pumping as the cause in our case. First, the apparent excess power at I_c=5 A was a steady 1.44 W/A at essentially room temperature, requiring an effective differential Seebeck coefficient

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$\Delta S=5.27\times10^{-3}$ V/°K; recall that $\Pi=ST$ and $P_{te}=I_c \Delta P=I_c T_a \Delta S$. This value of ΔS is several times that observed even in semiconductors.

Second, a proportionality of excess power to I_c is not supported by the data plot in Figure 7. In contrast, this plot suggests onset of saturation or even interference with rising I_c. Our last, weaker comment is that in our case the P_{te} into the cell vessel is theoretically zero because the electrolysis electrodes exiting the lid are identical. This reduces the problem to one of heat pumping between the junctions in the air space below the lid and the effectively Pt-Ni junction in the electrolyte below. However, no cooling of the exiting electrodes was ever discerned.

To account for an of the observed excess heat by hydroge-oxygen recombination within the cell requires a recombination efficiency of quite a high magnitude in our case. This efficiency,

$$\eta_{rec} = -\tilde{P}_{th}|_{\Delta T=0}/(1.48 I_c) \qquad (13)$$

follows from Eq. 7 by setting P_{exc} to zero and neglecting P_{te} and P_{st}. The plot of this η_{rec} in Figure 9, based on the previously

derived values of $-\tilde{P}_{th}|_{\Delta T=0}$ at the selected

I_c, shows that in the dc case for I_c below 10 A the η_{rec} exceeds 0.55 and grows rapidly to unity at I_c near 5 A. However, our data does marginally admit such an explanation. First, any recombination heat released in the air space between the electrolyte and the leaky lid, where the most active exposed catalyst was nickel wire connecting to the cathode, could hardly be well transmitted to the liquid below. Hence the recombination would have to be within the electrolyte. Using $L_{ev}(I_c) \approx L_{ev}(0)$ as argued below Eq. 12 for low Is, and the experimental data in Figure 8, the loose upper bound on η_{rec} imposed by Eq. 9 falls somewhat below the plot of Eq. 13 in Figure 9. Presumably Eq. 12 restricts η_{rec} even more. Our sparse water addition data thus seems not to entirely favor the recombination explanation, but fails to be decisive either way for lack of accurate L_{ev} data.

In a recent paper(23) applicable to water-based electrolytic cells, J.E. Jones et al. point out the well known(24) effectiveness of Ni, Pt, and Pd to catalyze the recombination of oxygen and hydrogen. They present electrolytic cell experiments demonstrating the quenching of apparent excess heat in configurations that inhibit the transport of dissolved oxygen to the cathode and hydrogen to the anode. And they further demonstrate the achievement of $\eta_{rec}>0.95$ when O_2 was bubbled through an operating cell. Accepting these results, our data are then generally consistent with the recombination explanation and the behavior of the apparent excess heat with cell current that it predicts.

The fact that the initial slope of the apparent excess heat versus I_c data shown in Figure 7 is comparable to the slope (1.48 W/A) of the maximum gas power line is as predicted at low current density by the recombination hypothesis; the solution of gas becomes more effective at low evolution rates. Related to this, the few reported dc tests of cells nearly identical to the present one, except for the nickel, also suggest a similar slope, even though they produced up to 50 W excess(15). Only the pulse mode, not systematically explored here, seems to have produced significantly more energy per coulomb throughput. Therefore, given an equal area of nickel wire, the indications now are that the metallurgy of the nickel greatly affects the saturation P_{exc} but probably less so the initial P_{exc}/I_c slope. In fact, subsequent testing of the present cell by the HydroCatalysis Power Corp. has verified our observations of its low saturation P_{exc} under the same conditions that produced 50 W excess from cells differing only in the source of the nickel wire. For the cell we examined, evidently there was an unfortunate choice of nickel wire from an untested source.

No conclusions can be drawn here regarding exothermal chemical reactions involving the electrodes, because the run times at each cell current and heater power were usually restricted to the minimum needed to establish thermal equilibrium - about 24 hours. However, no ordinary chemical reactions involving nickel are known that could account for the total excess energy from similar Mills type cells claimed to produce 50 W excess for months. And no report of a chemical or metallurgical change of the nickel cathode is known to us.

SUMMARY AND CONCLUSIONS

The light water-Ni-K_2CO_3 electrolytic cell on loan from the HydroCatalysis Power Corporation clearly exhibited the phenomenon of apparent excess heat when tested at 4 selected dc currents and one pulse mode current. Data was collected using simple 'on-the-fly' calorimetric calibration in the thermal steady state

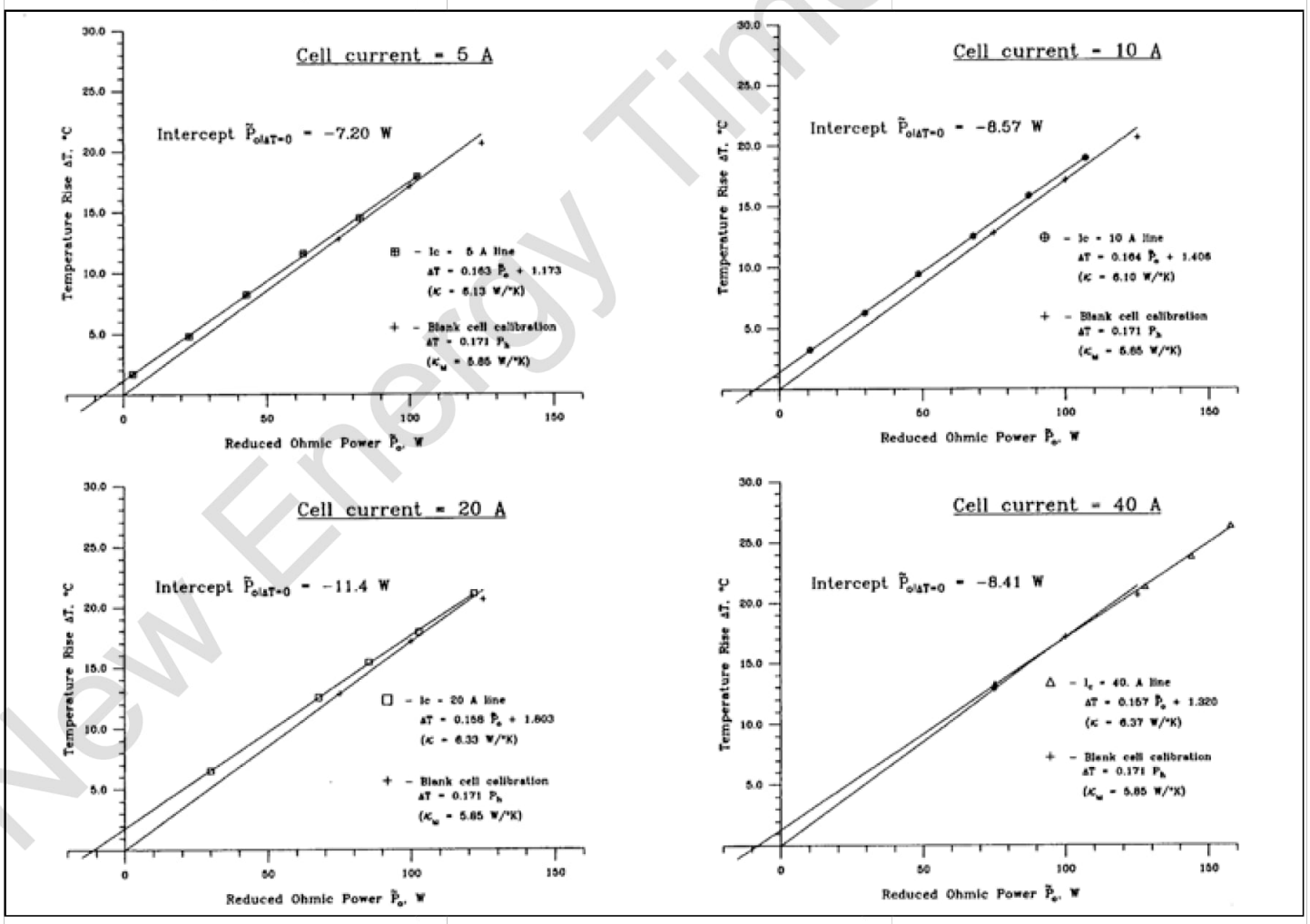

Figure 4. On-the-fly thermal calibration of the active cell for 4 selected dc electrolysis currents. The apparent excess heat is the negative intercept $-\tilde{P}_o|_{\Delta T=0}$ of the fitted line with the $\tilde{P}_o$-axis . The blank cell calibration line is repeated ineach plot for comparison of thermal conduction.

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and was reduced to give the apparent excess heat by extrapolation methods that are accepted practice in the field of anomalous heat cell ('cold fusion') research.

Our main findings regarding cell voltages, currents and powers are summarized in Table I. The apparent power gains ranged from 1.06 to 1.68. The apparent excess power of this particular cell saturated at a rather low 11.4 W. at an electrical input power of 59.6 W. using a cell currant of 20 A dc, as compared to about 50 W apparent excess reported by other workers for essentially the same cell. We attribute this shortfall to an unfortunate choice of untested nickel from an alternate source.

The power gain given in Table I and plotted in Figure 10 is based on the appar

ent excess power ($-\tilde{P}_{th}|_{\Delta T=0}$) and is the most optimistic possible, since gas recombination, stirring power and any thermoelectric heat injection are then neglected (see Eq. 7). The maximum possible gas power ($1.48I_C$) is included as part of the output power. The plot of the gain $(P_{exc,apparent} + P_C))/P_C$ in Figure 10 appears of a form decreasing asymptotically to unity for large I_c, as expected for a saturating $P_{exc,\ apparent}$.

Although our data admits the existence of an unusual source of heat within the cell, it falls far short of being compelling. To delimit the alternatives, we have examined the following factors considered in the literature as potential ordinary causes of multiwatt level, steady state, apparent excess heat in the present type of cell:

1. Unrecognized nonlinearity in the cell thermal conductivity (κ) at low temperature differential (ΔT), leading to erroneous extrapolation for the excess heat.

2. Injection of heat into the cell by thermoelectric pumping (Seebedk effect).

3. Exothermic chemical reactions involving the nickel cathode.

4. Heat from hydrogen-oxygen recombination within the cell

And we have come to terms with these possibilities as follows:

1. Nonlinearity in κ is contraindicated by the good alignment of our high power thermal calibration points with a straight line through the origin and also by the linear alignment of our 'on-the-fly' calibration points reaching down below 10 W. This linearity was achieved by forced convective cooling.

2. For thermoelectric heat pumping to account for the apparent excess heat would require differential Seebeck coefficients several times those of even semiconductors. Also, such heat pumping through the lid of our cell is zero in first order because the two exiting electrodes were identical.

3. The apparent energy evolved in the present experiments was inadequate to eliminate chemical reactions - runs too short for the power observed. However, this possibility has been examined and rejected by other workers operating very similar cells at 50 W apparent excess heat for months.

4. Our inadequate water accounting data are at least marginally consistent with the recombination explanation of the somce of the apparent excess heat, even though this requires recombination efficiencies exceeding 0.55 at 10 A and rising to near unity at 5 A of cell current Figure 9). Nevertheless, J.E. Jones et al.(23) have claimed to show that light water cells with nickel and platinum electrodes can indeed achieve such high recombination of dissolved oxygen and hydrogen. Also, our Figure 7 suggests this possibility.

Following the principle of simplest explanation that fits the data on hand, recombination becomes the explanation of choice. But even perfect recombination

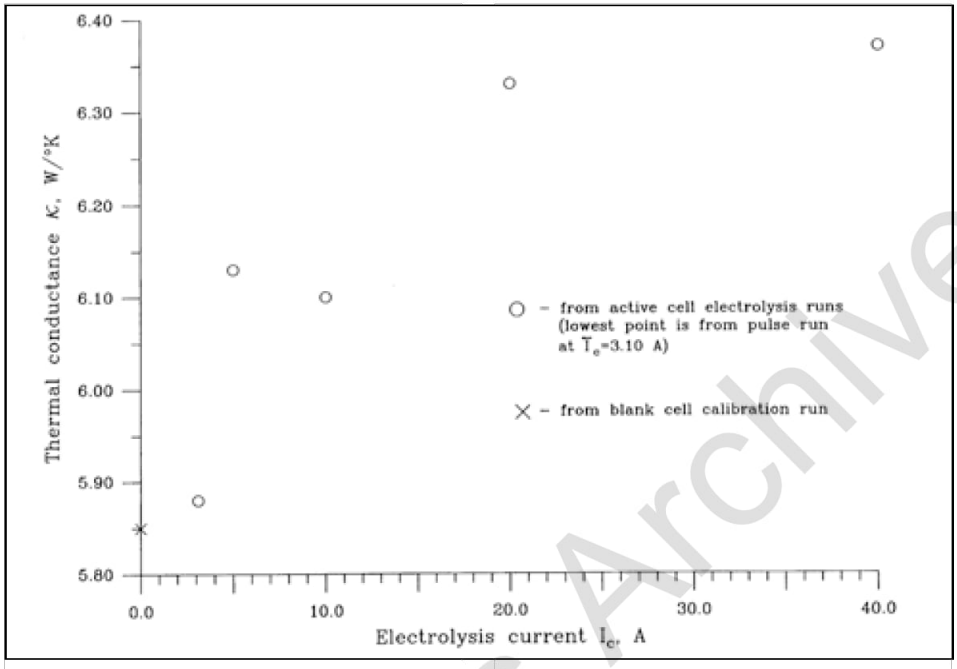

Figure 5. Scatter plot of cell thermal conductance κ versus electrolysis current I_c, showing κ for the blank cell and all active cell runs.

cannot account for all of the apparent excess heat in those Mills cells usually operated in a pulsed current mode and reported to produce a thermal output solidly exceeding the VI power input to the cell. These cases at least leave the door open to more interesting possibilities. Consider-ing the potential value of a new energy source, it seems worth while to restudy the Mills type cell in configmations allowing an accurate account for recombination and water loss.

Insufficient resources prevented us from proceeding with a more careful study of the excess heat effect in cell types adapted to bear on specific questions. For example, certain gaseous loading types, such as the D_2-Pd transient pressurizing experiment (25) at NASA or the H_2-Ni heating experiments at the University of Siena, could avoid the complications of electrolytic cells, while exploring possibilities of high temperature operation and radiation emission (27).

ACKNOWLEDGMENTS

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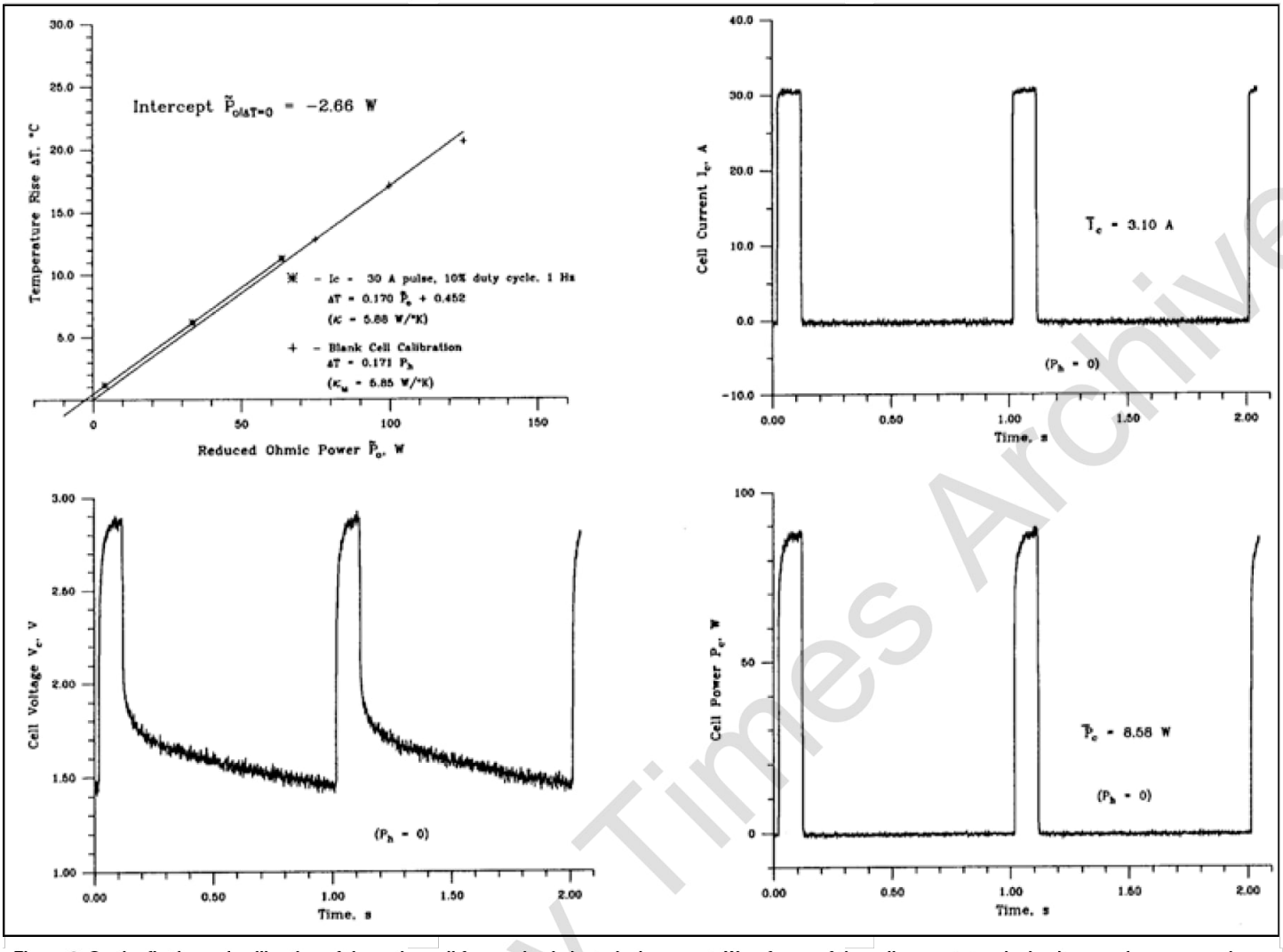

Figure 6. On-the-fly thermal calibration of the active cell for a pulsed electrolysis current. Waveforms of the cell current, terminal voltage and power are shown at thermal equilibrium for zero heater power. Note near equality of active and blank cell thermal conductances.

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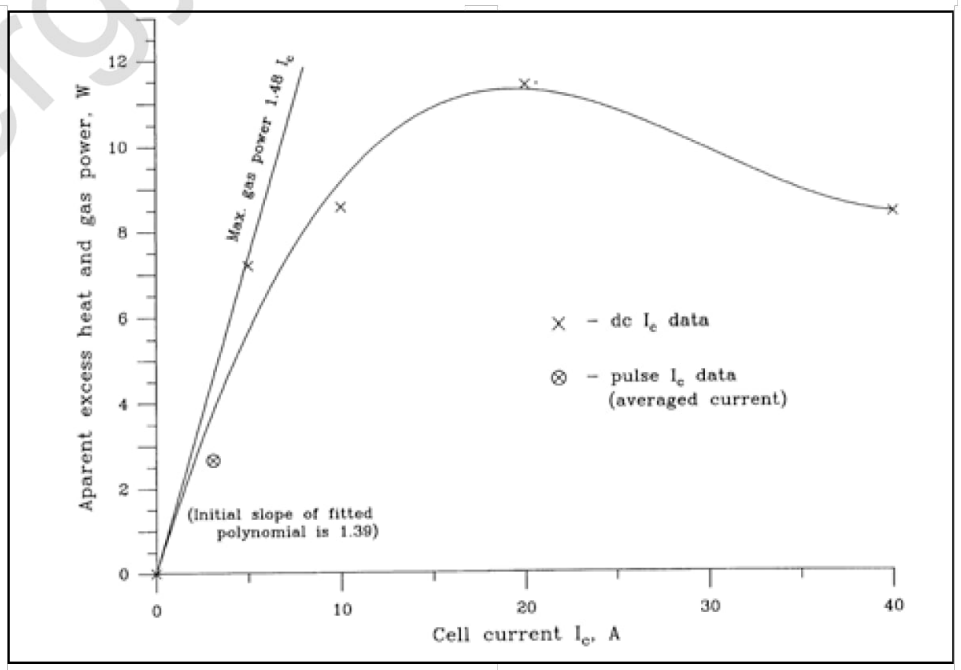

Figure 7. Plot of apparent excess power ($-\tilde{P}_o|_{\Delta T=0}$) versus cell current I_c for all electrolysis runs. The fitted curve is a cubic polynomial through the origin, but has no special significance. The maximum gas power line is shown for comparison.

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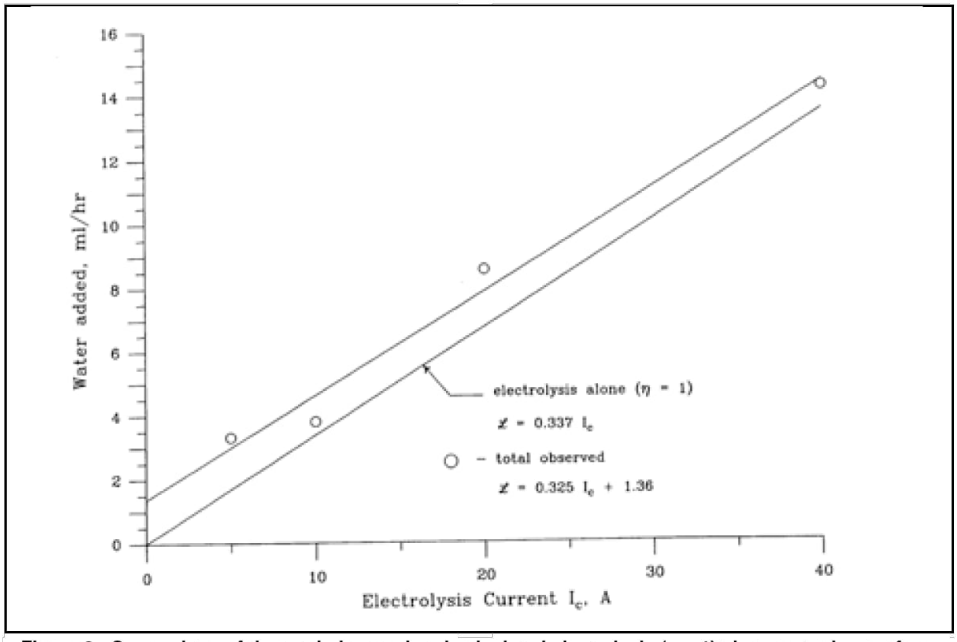

Figure 8. Comparison of the total observed and calculated electrolysis (η = 1) alone water losses from the active cell at trhe four selected cell currents I_c.
At each I_c, the losses have been averaged over the selected heater powers.

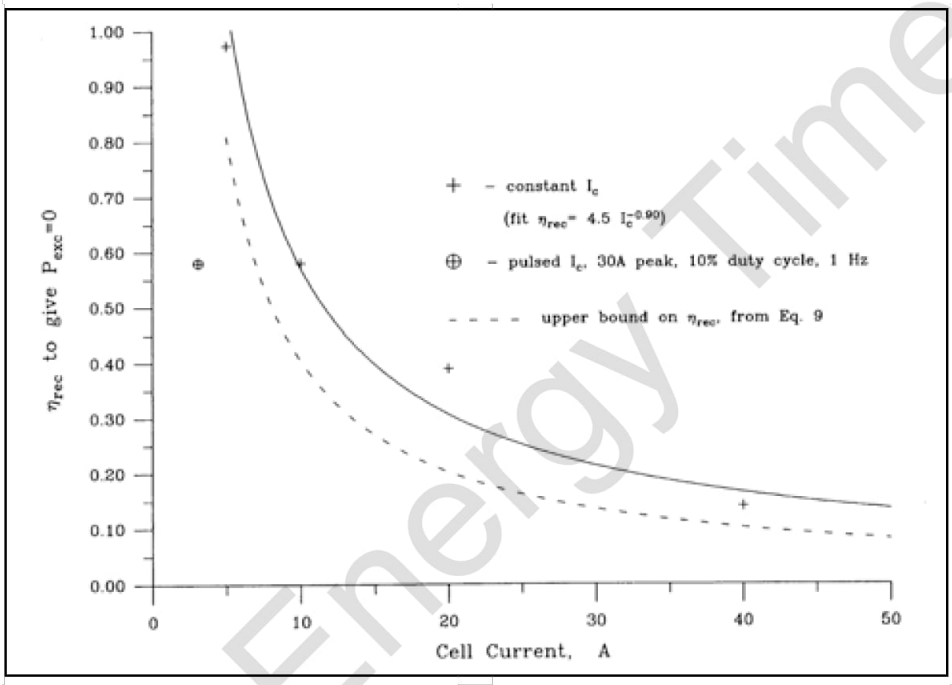

Figure 9. Oxygen-hydrogen recombination efficiency needed to account for all of the apparent excess heat at each of the experimental runs. Dashed curve shows the upper bound on η_{rec} imposed by Eq. 9 and experimental data of Fig.8.

Continued from p.52

some aspects of Green thought, recently overshadowed by the urgent necessity of solving the mechanical problems of energy and pollution, can now come closer to the fore and we can concentrate more on encouraging a satisfying, less trivial, lifestyle that respects the Earth and the other life that we share it with. Ultimately, of course, to want a genuinely satisfying life is self-centred, but how much more viable it will be than our current selfish consumerism that had set us on a one way journey towards exhausting the resources of the Planet. Earlier, I touched on why the advent of abundant energy will lead to the fading away of consumerism and the seemingly paradoxical enrichment of the majority of humanity. I could be wrong, but the prospect is now before us and I think we should work towards it.

There is one group who claim to have a device that turns radioactive thorium into its normal decay products in half an hour [*Ed. note—see IE #5&6.*] - this technology may eventually hold out the prospect of remediating nuclear waste and disposing of the large amount of plutonium cluttering up the Planet that is the legacy of the nuclear industry. The sky looks like the limit —nobody yet knows all that we will be able to do with these inventions and the knowledge that will follow from them - what is certain is that we will eventually be able to do things that we haven't even thought of yet.

As environmentalists we cannot oppose these new energy sources, although some factions of the movement, those prone to the more Thoreau'esque sentiments, will continue to root for a back-to-nature way of life. Ironically, this may come about — with energy on tap it will be possible to "homestead" in the wilds with most of the comforts of civilization —what this will do to the heart and soul of such people is anyone's guess as yet, but it will have to be healthier than being a powerless cog in a giant and impersonal corporation in an increasingly anonymous world.

Arthur C. Clarke made a brief appearance in the BBC Equinox programme which featured cold fusion. He made an important point that if we do get access to all the energy our hearts desire, then we may generate a different form of global warming because of the waste heat that we would create. It's not much good solving global warming by returning greenhouse gases to normal levels if we then proceed to destabilize the atmosphere in another way. Considering that the Patterson CF cell has operated at a power density of around 35 watts/ml recently, I think we should watch this aspect. This power density doesn't sound much but, scaling up, it becomes 35 kilowatts per liter and a staggering 35 megawatts per cubic meter. The human population is forecast to stabilize at around 11 billion by the middle of the next century, and if each human was then using a constant 30 kilowatts, which may very well happen if we have unlimited energy to run our homes, transport, and manufacturing processes etc., then we would be adding around an extra 1/750 of the heat that Earth inter-cepts from the sun. This might be insignificant globally, but as the climate seems to have a fractal nature and be vulnerable to the "butterfly effect," it may conversely have large effects. Fractional changes in the solar insolation due to tiny variations in Earth's orbit are thought to account for the periodicity of ice ages. In any event, the outpouring of so much waste heat in areas of high population density would certainly have an effect on the local micro-climate, and so this effect should be guarded against — it may be that we will need to radiate the waste heat into the night sky to get rid of it.

Arthur C. Clarke was also featured in the first issue of *Infinite Energy* and so I think it appropriate to finish off this article with a reference to his famous novel "2001 - A Space Odyssey." At the end of "2001" the newly created and fantastically powerful Star Child floats in space, near to Earth; it didn't know yet what it would do next, BUT IT WOULD THINK OF SOMETHING. The same infinite destiny could await us.

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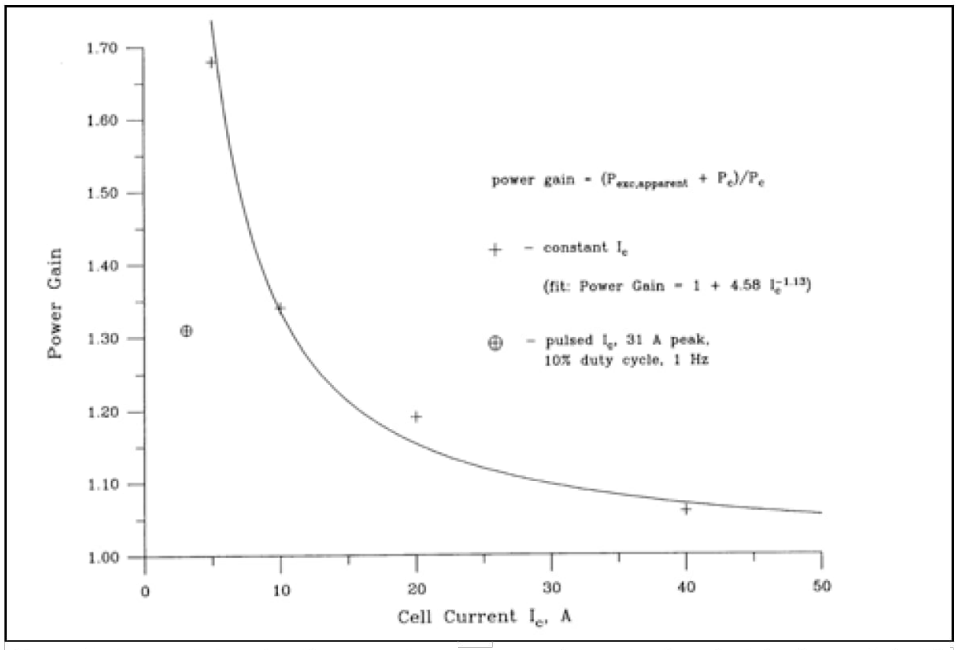

Figure 10. Power gain based on the apparent excess power observed at the selected cell currents I_c. All chemically stored energy is considered as part of the output.

I_c (A)	V_c (V)	Duty Cycle (%)	$V_c I_c$ (W)	$P_{exc, apparent}$ (W)	Apparent Power Gain(3)
5.0	2.12	100	10.6	7.20	1.68
10.0	2.55	100	25.5	8.57	1.34
20.0	2.98	100	59.5	11.4	1.19
40.0	3.36	100	134.5	8.41	1.06
31.0(1)	1.72(2)	10	8.58(2)	2.66	1.31

Table I. Operating characteristics of HydroCatalysis Power Corporation's demonstration light water-Ni-K_2CO_3 electrolytic cell.

(1) Peak current of rectangular pulse.
(2) Time average
(3) Apparent Power Gain = $(P_{exc,apparent} + V_c I_c)/(V_c I_c)$
Note: usual test duration was about 24 hours at each fixed I_c and heater power.

Cravens; Continued from p.16

of the periodic chart, on that row -- I guess that's the third one. [Fourth, counting H, He as row number 1.] And you see that for example, copper-63 went from . . . naturally it occurs at 60 some odd percent *[Eds: should be 70%]*, but the copper-63 that they find in the electrodes are 100%. So either these guys are faking it with isotopic ratios that we cannot find on the planet, or we are producing isotopic shifts of some kind. It looks like we are *producing copper*. We have done analyses, and we see . . . [aside to CETI CEO, Jim Reding] Can I say which elements we see? [Inaudible response] Okay, the copper and the silver, maybe palladium, and that sort of stuff. We are seeing isotopes, those type of things, being formed. And we have got it through mass spec, we have got it through neutron activation, we have done x-ray fluorescence. At least three locations have done the analysis on the beads. The nice thing with the nuclear [evidence]: you can give them a handful of beads before and after, and they can go run it off. You get a thousand little beads in the little pack, and they can do all the analysis you want. And you can ship them all over the country. Whereas temperature measurements, you have got to be there, *then*, and have the thermometer in the right place. You know, so the temperature measurements are a little bit . . . hmm, is it or isn't it, but the nuclear is fairly strong because you can ship these things around and get analysis and major labs with the best equipment for that measurement. So we are lining that kind of stuff up. We know that as soon as we deliver this we are going to be in the middle of a firestorm. Because people are not ready to, uh . . . (laughs). You know, they may accuse us of: (low voice) "well, you just put in copper-63 in there, without any copper-65. And you are producing silver-107 and 108 at different ratios than natural abundance, and sort of flipping them" -- and various things like that. But . . . tell me how we could do that?!? On our kind of budget. I mean, it would take Russia to do that kind of thing. (Laughs) You're not going to do that. So we are seeing these kinds of things, and it is not just us; there are people at Texas A&M and in Japan that are also seeing these *types* of things. I think we are doing it a lot better. It is just that we haven't publicized it for various legal and various other reasons.....

Dr. Cravens on Commercialization:

"Clean Energy Technology Inc. is located in Dallas, Texas. For those that want to know the World Wide Web site is cleanenergy.com/ceti. CETI. That's not search for extraterrestrials, that's clean energy technologies, and it's not the Colorado Eye Trauma Institute. Those are the other things on the net which you might get it confused with. Any business things and all, should go to that location. They have a PR firm to handle questions by media and other things. People who say we should be already selling these things at Wall Mart or Kmart red special -- red light? Blue light special -- and stuff like that, don't really understand the real world and what it takes to get there. It takes a lot of people. We are getting crackerjack electrical engineers, polymer scientists, we are doing . . . it would amaze you how many board tables we have done demonstrations on: major utilities and major Fortune 500 companies and that sort of stuff. So that sort of stuff is going on, so people who say 'why aren't they doing this?' -- they don't know what's going on. If you are -- I am going to pick a company at random: TI. (We don't have any dealings with them, except we share a law firm I think, setting patent strategy for international stuff. You have got to have heavy hitters in this league.) If you were a TI starting a new chip, you don't advertise to the world 'here it is, and this is what we are going to do, and this is what we are going to put in it, first.' Some of that may leak out. But you don't know what's going on back there. And we can't tell you all that."

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TAPE#2

Buford ("Ray") Conley
(MIT, graduate student, Dept. of Aero/Astro Eng.)
"Light Water Excess Heat Experiments"
Fred Jaeger
(ENECO, Salt Lake City)
"Patents and Commercialization"
Professor Peter L. Hagelstein
(MIT Dept. of Electrical Engineering and Computer Science) "Cold Fusion: What We Know and What We Don't Know"

TAPE#3

Professor Peter Hagelstein
(CONTINUED from TAPE #2)
"Cold Fusion: What We Know and What We Don't Know"
Professor Keith Johnson
(MIT Dept. of Materials Science and Engineering)
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"The Hydrosonic Pump: Excess Power and Other Effects"

TAPE#4

Bertil Werjefelt
(PolyTech(USA), Hawaii)
"Energy from Magnetic Materials and Magnetic Fields"
Dr. Eugene F. Mallove
(Cold Fusion Technology, Concord, NH)
Concluding Remarks

The tapes include the speakers' presentations as well as question and answer sessions. There is footage of the Hydrosonic Pump under test as well as close-up footage of rotor surface melting effects. Bertil Werjefelt shows footage of experiments in his own laboratory. There are scenes of Japanese researchers from Sumitomo, Hitachi, and other companies and universities now involved in their claimed extraction of energy from magnetic materials. These efforts are now said by these researchers to be proceeding toward commercialization. Actual experiments are seen in progress. The tapes are VHS cassettes in NTSC format and range from 120 to 127 minutes each.

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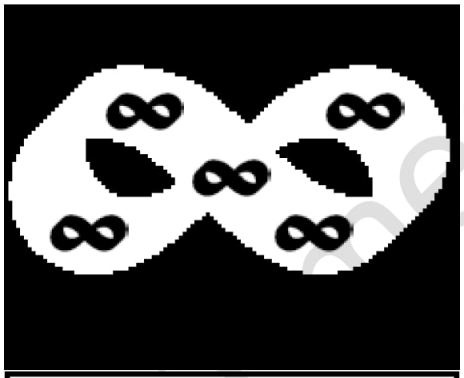

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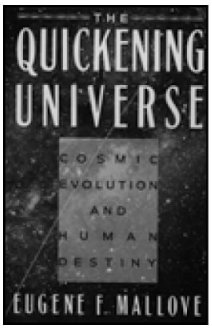

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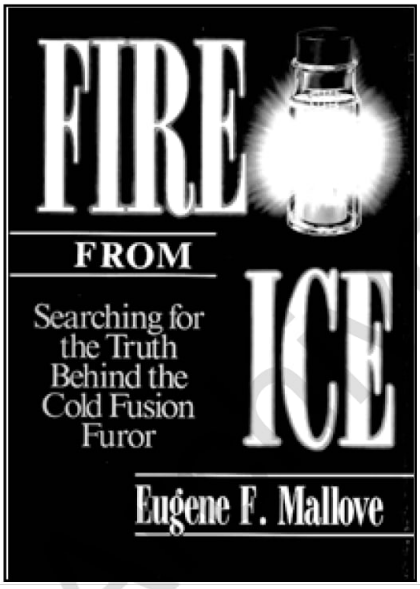

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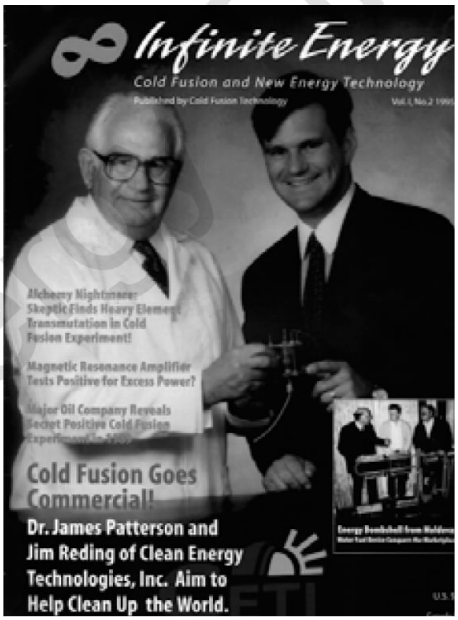

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